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Original Article

Measuring Health Literacy in Childhood and Adolescence with the Scale Health Literacy in School-Aged Children – German Version

The Psychometric Properties of the German-Language Version of the WHO Health Survey Scale HLSAC

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Abstract: Health literacy can help explain health inequalities in childhood and adolescence. However, suitable instruments for assessing health literacy in this age group are rare, especially in the German-speaking countries. One economical measure is the 10-item Health Literacy in School-Aged Children (HLSAC) scale, developed and reviewed as part of the WHO Child and Adolescent Health Study (HBSC, Health Behavior in School-Aged Children). In the present study, we tested dimensionality, measurement invariance, and associations with health-related measures of the German version of the scale (HLSAC–German), using data from the 2018 national German HBSC study (N = 4,347 students aged 11, 13, and 15 years). We also tested HLSAC–German with 11-year-olds, representing an expansion of the original scale. Exploratory and confirmatory factor analyses consistently demonstrated the unidimensionality of the scale (α = .88). Complete scalar measurement invariance was found for sex and partial scalar measurement invariance for age groups and school type, allowing for the comparison of means. Associations with indicators of health and health behavior further demonstrate the construct validity of the scale. The analyses show that the scale is suitable for the economic measurement of a general factor of health literacy in 11- as well as in 13- and 15-year-olds.

Keywords: health literacy, childhood, adolescence, measurement invariance, validity

Messung der Gesundheitskompetenz im Kindes- und Jugendalter mit der Skala „Health Literacy in School-Aged Children-German" (HLSAC-German). Psychometrische Eigenschaften der deutschsprachigen Version einer Skala aus der WHO Kinder- und Jugendgesundheitsstudie HBSC

Zusammenfassung: Die 10-Item-Skala „Health Literacy in School-Aged Children" (HLSAC) ist ein ökonomisches Verfahren zur Messung der Gesundheitskompetenz im Kindes- und Jugendalter, das im Rahmen der HBSC-Studie (Health Behavior in School-Aged Children) entwickelt und überprüft wurde. Im vorliegenden Beitrag werden die Dimensionalität und Messinvarianz der deutschen Version der Skala, HLSAC-German, sowie Zusammenhänge zu gesundheitsbezogenen Indikatoren anhand der Daten der deutschen HBSC-Studie 2018 (N = 4 347 Schülerinnen und Schüler im Alter von 11, 13 und 15 Jahren) überprüft. Der Einsatz in der Gruppe der 11-Jährigen stellt eine Erweiterung im Vergleich zur Originalskala dar. Explorative und konfirmatorische Faktorenanalysen belegen die Eindimensionalität der Skala (α = .88). Es zeigen sich vollständige skalare Messinvarianz bezüglich des Geschlechts und partielle skalare Messinvarianz bezüglich Altersgruppen und Schulform, welche Mittelwertvergleiche erlauben. Erwartungsgemäße Zusammenhänge zu Indikatoren der Gesundheit und des Gesundheitsverhaltens belegen weiter die Konstruktvalidität der Skala. HLSAC-German ist zur ökonomischen Messung eines allgemeinen Faktors der Gesundheitskompetenz sowohl bei 11- als auch bei 13- und 15-Jährigen geeignet, wobei die Dimensionalität in der jüngsten Altersgruppe weiter überprüft werden sollte.

Schlüsselwörter: Gesundheitskompetenz, Kindesalter, Jugendalter, Messinvarianz, Validität

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The foundations of many health-related behaviors are laid in childhood and adolescence, underscoring the importance of studying health literacy at this particular juncture (Bollweg & Okan, 2019; Firnges et al., 2019; Paakkari et al., 2016). In recent years, across different disciplines, international research on the subject has taken heterogeneous approaches to and prepared various definitions and operationalizations of the concept of health literacy (Soellner et al., 2009; Sørensen et al., 2012).

Within these varied approaches, we can differentiate a range of basic currents with fluid transitions. On the one hand, there is an understanding prevalent in the current discussion that describes health literacy as the ability to acquire, handle, and process health-related information (e.g., Caldwell & Melton, 2020; Quenzel et al., 2015; Sansom-Daly et al., 2016; Schaeffer & Pelikan, 2017; Sørensen et al., 2012). On the other hand, some concepts understand health literacy as a broad spectrum of action and regulation competencies (e.g., Kriegesmann et al., 2005; Lenartz, 2012; Nutbeam, 1998; Paakkari & Paakkari, 2012; Paakkari et al., 2020; Soellner et al., 2010). Between these two poles lies a range of conceptualizations that build on both understandings and include, for example, the use of health-related information and other competencies, such as interaction skills and health-related attitudes (Domanska et al., 2021).

The present study views health literacy as a broad set of action and regulation competencies, in particular, based on Paakkari and Paakkari's (2012) conceptualization of health literacy. In this approach, people should be able to make informed and reflective responsible decisions about their own health, while also recognizing and considering the connections between their health and their environment, the natural world, and society. According to Paakkari and Paakkari, this requires (1) theoretical knowledge, (2) practical knowledge, (3) critical thinking, (4) self-reflection (self-awareness), and the (5) recognition of ethical and social responsibility (citizenship). These five dimensions of health literacy can be assessed with the Health Literacy for School-Aged Children (HLSAC; Paakkari et al., 2016) scale. The present study assesses the psychometric properties of the German-language version, the HLSAC–German.

Health Literacy in Childhood and Adolescence

Compared to the many findings for adulthood, there are relatively few findings on health literacy among children and adolescents, and theoretical conceptions generally refer only to adults (Bröder & Carvalho, 2019; Guo et al., 2018; Lane & Aldoory, 2019; Okan et al., 2015). The studies that have been conducted show associations between the expression of health literacy and risk and health behaviors in childhood and adolescence. This is the case regardless of the underlying understanding of health literacy. For example, consumption of healthy foods, such as fruit and vegetables, and daily physical activity are positively associated with adolescent health literacy (Domanska et al., 2021; Quenzel et al., 2015), whereas negative associations emerge with obesity or substance use (Fleary et al., 2018; Sansom-Daly et al., 2016).

Against this background, the goal is to achieve a high level of health literacy in childhood and adolescence. However, the few available studies point to relatively low levels of health literacy in childhood and adolescence (Caldwell & Melton, 2020; Paakkari et al., 2020) – both when health literacy is conceived of as the ability to understand and process health-based information (Caldwell & Melton, 2020) and when health literacy is defined as a more complex set of skills (Paakkari et al., 2020). Some but not all studies report higher levels of health-based competence in girls (Paakkari et al., 2020). More consistently, adolescents from families with a higher socioeconomic status and educational background are found to have higher levels of health literacy (Caldwell & Melton, 2020; Fleary et al., 2018; Quenzel et al., 2015). Most studies do not find associations with age or grade level (Caldwell & Melton, 2020; Fleary et al., 2018), so increases in health literacy are not necessarily related to longer school attendance. This makes it all the more important to specifically address health literacy as an educational subject (Bilz, 2021; Dadaczynski et al., 2021; Ormshaw et al., 2013; Paakkari & Paakkari, 2012) and flags the importance of developing appropriate measurement instruments to, for example, evaluate the success of these kinds of educational measures.

Measuring Health Literacy in Childhood and Adolescence

Measuring health literacy in childhood and adolescence should consider the complexities of this construct and be appropriate for the age group in question (Okan et al., 2015; Velardo & Drummond, 2017). However, the methodological development of such survey instruments is still in its infancy and often does not include a broad set of action and regulation competencies (Bollweg & Okan, 2019; Dadaczynski et al., 2021; Fleary et al., 2018; Guo et al., 2018; Sansom-Daly et al., 2016), especially

for instruments used in the German-speaking countries (Firnges et al., 2019).

For primary school-aged children, for example, one can measure health literacy using a quiz-based assessment (QUIGK-K) that maps four processes of information intake and processing (access, comprehension, evaluation, application) relative to five health topics (physical activity, nutrition, media, psychosocial health, healthcare) (Teufl et al., 2020). For 9- and 10-year-old children, there is also an adapted German-language version of the HLS-EU-Questionnaire, based on 15 items, which measures access to as well as understanding and use of health information (HLS-Child-Q15; Bollweg et al., 2020). A broader questionnaire-based instrument is available for adolescents aged 14 to 17 years, the MOHLAA-Q, which measures health literacy with 29 items using the dimensions handling health-related information, communication and interaction, attitudes toward health, and health-related knowledge (Domanska et al., 2020, 2021). The HLSAC scale represents a measurement instrument that captures health literacy exclusively in terms of the conceptualization by Paakkari and Paakkari (2012) described above. It was first used in Germany in 2018 as part of the HBSC (Health Behavior in School-Aged Children) study and is the subject of this paper. Other methods such as questionnaires or quizzes have been designed in the context of other studies on individual questions (e.g., Splieth et al., 2015; Wallmann et al., 2012), but these are not based on a multistage process of test development and validation.

The HLSAC–German Scale

The HLSAC–German scale is the German translation of the HLSAC scale (Paakkari et al., 2016; for details on the translation, please see the Methods section). As described above, the authors of the scale assume that health literacy enables people to reflect on their own needs, the needs of others, and their environment in a way that allows them to make informed health decisions and influence their own health-related risks and resources (Paakkari et al., 2016).

The HLSAC scale was developed in Finland in a multistage process in which 10 items were empirically extracted from an originally developed pool of 65 items (Paakkari et al., 2016). The following five postulated components of health literacy are assessed with two items each: theoretical knowledge, practical knowledge, critical thinking, self-awareness, and citizenship (Paakkari & Paakkari, 2012; see Table 1). The data basis for creating the short questionnaire was a Finnish sample of 13- and 15-year-olds from the HBSC study from 2013/2014. Confirmatory factor analyses showed a good fit for both a 5-factor and a 1-factor solution of the scale, whereby the authors preferred the 1-factor solution because of high intercorrelations of the factors (Paakkari et al., 2016).

Findings on risk and health behaviors supported the construct validity of the scale. For example, the total health literacy score (single-factor) correlated with toothbrushing behavior, physical activity, sleep duration, dietary behavior, and alcohol and tobacco use, whereby in each case the correlation was small but significant (Paakkari et al., 2019). In addition, expected associations were reported with subjective health status, tendency to strive for a healthy lifestyle, and internal health-related loci of control beliefs (Haney, 2018; Mazur et al., 2019; Paakkari et al., 2020).

The international use of the HBSC study raised the question of the cross-national comparability of the HLSAC scale. The measurement invariance of the unidimensional scale concerning different language versions was tested with data from Finland, Slovenia, Poland, and Belgium (Paakkari et al., 2018). The results showed that international comparisons of health literacy scores based on mean scores obtained with different language versions of the scale are valid (Paakkari et al., 2018). Reviewed and validated versions of the scale using national samples are currently available for Turkey (Haney, 2018), Poland (Mazur et al., 2019), Italy (Velasco et al., 2021), and Denmark (Bonde et al., 2022). The Polish, Italian, and Danish versions of the scale were shown to be unidimensional (Bonde et al., 2022; Mazur et al., 2019; Velasco et al., 2021); for the Turkish version, the 5-factor model proved to be fitting. The dimensionality of the HLSAC–German scale has not been tested before.

Compared to the other three German-language survey instruments for health literacy in children and adolescents outlined above (QUIK-K, HLS-Child-Q15, MOHLAA-Q), with 10 items, the HLSAC–German scale represents the most economical procedure. Because of its brevity, the procedure is, in principle, suitable for use in schools (Guo et al., 2018) and could also be used in larger social epidemiological studies to support further research on health literacy during childhood and adolescence. However, this requires the German-language version of the scale to show sufficient psychometric qualities.

Aims and Research Questions

This paper examines the HLSAC–German scale in terms of its psychometric properties. To this end, we will begin by analyzing the factorial validity of the scale in terms of dimensionality and measurement invariance with respect to sex, age groups, and school types. Furthermore, we

investigate whether the scale can be used for a cohort of 11-year-olds, since the original HLSAC scale was not validated in this youngest age group within the HBSC study. Concerning dimensionality, we examine whether the 5- or 1-factor solutions postulated for the HLSAC scale better reflects the data structure of the German version. Since both dimensionalities are reported in the literature in some cases, a general factor solution on the second level in the sense of a second-order structure is also conceivable (5 factors on level 1 forming a global factor on level 2). Thus, we examine this for the German version. To further test construct validity, we also examine group differences and associations between health literacy and subjective assessment of mental health as well as with behavioral measures of risk and health behavior (physical activity and alcohol consumption), taking into account the previously determined dimensionality. We expect that higher health literacy scores are associated with better mental health, more physical activity, and lower consumption of alcohol – with associations of small (related to the behavioral measures) to moderate strength (related to mental health).

Method

Sample

The data for this study were drawn from the German sample of the 2018 HBSC survey. Students in grades 5, 7, and 9 at general schools in all German federal states were surveyed using written questionnaires. Participating schools were selected using a stratified random sample (stratification characteristics: state and type of school), and the percentage distribution of learners across states was considered in the sample design (Moor et al., 2020). Through the central data center of the HBSC study, the data were then cleaned to allow us to focus on the same age groups across all states, meaning that only students who were 11, 13, and 15 years old at the time of the survey remained in the sample (Moor et al., 2020). In addition, the German consortium of the HBSC study decided to categorize school types across the federal states (Moor et al., 2020). Thus, it distinguished between lower secondary schools (*Hauptschulen*), intermediate secondary schools (*Realschulen*), grammar schools (*Gymnasien*), and schools at which multiple educational qualifications can be obtained (mixed school type, such as comprehensive schools, community schools, compound schools).

Data are available on 4,347 students (53 % female) from 146 general-education schools in Germany, distributed almost evenly across the age groups under consideration (11 years: 32 %, 13 years: 33 %, 15 years: 35 %). The distribution of school types in the sample largely corresponds to the distribution of the student body across school types throughout Germany (lower secondary schools: 9 %, intermediate secondary schools: 18 %, grammar schools: 44 %, schools with multiple educational qualifications: 30 %). To increase the representativeness of the data for the German student body, we employed a weighting of the data by region, school type, sex, and grade level to compensate for small deviations in sample characteristics (Moor et al., 2020).

Procedure

The respective ministries of education and cultural affairs approved the study in all German states (excluding North Rhine-Westphalia, where approval by school administrators suffices). The randomly selected school principals were informed about the study in writing and by telephone. The participation of all schools as well as the individual participation of the students was voluntary, and student participation required the written consent of their legal guardians. The schools received all necessary materials, including informational flyers for parents and students, consent forms, and questionnaires. The survey took place during a school lesson and was supervised by teachers from the participating schools. Completed questionnaires were returned by mail in sealed envelopes to the respective survey centers (participating universities in the German HBSC Consortium).

Measures

HLSAC-German

Students' health literacy was assessed using the scale HLSAC-German. It was translated by native-speaking members of the HBSC Study Group Germany using a translation–backtranslation procedure. The scale consists of 10 items, each introduced with the partial sentence: "I am confident that …" Table 1 presents the items of the HLSAC–German scale in English translation for the present publication. The German-language version of the scale is presented in Electronic Supplement 1. The items are answered on a 4-point scale (1 = *not at all true*, 4 = *absolutely true*). The total value of the scale is represented by the mean value of the 10 items (theoretical range 1 to 4). Complete data are available from n = 3,726 students.

Subjective Health Complaints

A subjective mental health assessment was measured using the German-language version of the Strengths and

Table 1. Items of the HLSAC–German scale with mean, standard deviation, skewness, and kurtosis, item discrimination, and item difficulty in the total sample (N = 4,347)

Items	*n*	*M*	*SD*	Skewness	Kurtosis	Item discrimination	Item difficulty	Item discrimination: Correlations with ...	
								Subjective mental health	Physical activity
I am confident that ...									
(1) I have good information about health[TK]	4,122	3.13	0.75	-0.67	0.37	.54	71.00	-.23	.12
(2) when necessary I am able to give ideas on how to improve health in my immediate surroundings (e.g., a nearby place or area, family, friends)[CZ]	4,031	2.78	0.83	-0.36	-0.34	.56	59.33	-.12	.12
(3) I can compare health-related information from different sources[CT]	3,980	2.70	0.84	-0.31	-0.42	.62	56.67	-.12	.07
(4) I can follow the instructions given to me by healthcare personnel (e.g., nurse, doctor)[PK]	4,027	3.25	0.87	-0.98	0.14	.55	75.00	-.15	.02
(5) I can easily give examples of things that promote health[TK]	3,978	2.91	0.84	-0.45	-0.33	.66	63.67	-.12	.08
(6) I can judge how my own actions affect the surrounding natural environment[CZ]	3,968	2.97	0.84	-0.54	-0.26	.61	65.67	-.14	.07
(7) when necessary I find health-related information that is easy for me to understand[PK]	3,932	2.87	0.81	-0.44	0.21	.68	62.33	-.14	.05
(8) I can judge how my behavior affects my health[SA]	3,955	3.01	0.83	-0.60	-0.13	.63	67.00	-.17	.04
(9) I can usually figure out if some health-related information is right or wrong[CT]	3,935	2.80	0.84	-0.39	-0.34	.65	60.00	-.15	.04
(10) I can give reasons for choices I make regarding my health[SA]	3,941	2.96	0.83	-0.57	-0.13	.65	65.33	-.17	.08

Note. Theoretical assignment of the items: [TK] theoretical knowledge; [PK] practical knowledge; [CT] critical thinking; [S] self-awareness; [CZ] citizenship. Responses: Scale of 1 to 4 (1 = *not at all true*, 4 = *absolutely true*). All items: Median = 3.0; min = 1.0; max = 4.0. *SE* skewness: 0.04; *SE* kurtosis: 0.08. Item discrimination: Corrected correlation of the items with the scale. Item difficulty: Calculated from (((*M* – Min) / (Max – Min))*100). Item discrimination concerning external measures: Pearson's correlation coefficient of the respective item with subjective assessment of mental health (SDQ total problem score) and physical activity (average number of days of physical activity of at least 60 minutes).

Difficulties Questionnaire (SDQ; Goodman, 2005). We used the items on mental health (without the scale on prosocial behavior) from the self-report version for 11- to 17-year-olds. This version of the SDQ consists of a total of 20 items, with 5 items each representing four different groups of behavioral problems (emotional problems, externalizing behaviors, hyperactivity and attention problems, peer problems; e.g., "I worry a lot" for emotional problems). Responses are recorded on a 3-point scale (0 = *not true*, 1 = *somewhat true*, 2 = *certainly true*). The total problem score of mental health is formed by adding all answers, whereby higher values represent a worse mental health status (theoretical range: 0 to 40). In a study of the factor structure of the SDQ, the total scale showed satisfactory internal consistency (α = .77; Lohbeck et al., 2015). The internal consistency of the present data was comparable at α = .76. Complete data on the SDQ are available from n = 3,973 students. On average, respondents reported a mental health status of M = 10.5 (SD = 5.2; range: 0 to 36).

Physical Activity

Students' physical activity was recorded with at least moderate intensity realized for at least 60 minutes a day (Seven-Day Recall Method; Prochaska et al., 2001). This self-report was determined using a single item ("Over the past seven days, on how many days were you physically active for a total of at least 60 minutes per day?"), and responses were recorded on an 8-point scale (on 0 to 7 days). The item was preceded by an explanation of the physical activity, including examples and characterizations of intensity (increasing pulse rate, e.g., playing sports or running around with friends). To answer the item, students had to consider the total time spent doing physical activities in a day. The item had previously been reviewed in several studies, showing good to acceptable retest reliabilities (Bobakova et al., 2015; Prochaska et al., 2001). Data on physical activity were available from n = 4,299 students. On average, they reported being physically active for at least 60 minutes on M = 3.8 days (SD = 1.9; range: 0 to 7)

Alcohol Consumption

Students' alcohol consumption was assessed with a 30-day prevalence item ("On how many days (if any) have you drunk alcohol in the past 30 days?"; Inchley et al., 2018). Responses were recorded on a 7-point scale (1 = *never*, 2 = *1 to 2 days*, 3 = *3 to 5 days*, 4 = *6 to 9 days*, 5 = *10 to 19 days*, 6 = *20 to 29 days*, 7 = *30 days*). The students' statements were categorized for the analysis. A distinction was made between no alcohol consumption in the past 30 days (response option 1; reported by 75% of respondents), alcohol consumption on 1 to 9 days in the past 30 days (response categories 2 to 4; 23%), and alcohol consumption on at least 10 days in the past 30 days (response categories 5 to 7; 2%). Complete data on 30-day alcohol consumption were available from n = 4,266 students.

Demographic Variables

The demographic variables were sex (recorded in binary form, 1 = *boy*, 2 = *girl*) and age (month and year of birth, converted into age in years) as self-reported by the students. In addition, the type of school was included as a demographic variable. This was coded by the survey team and subsequently classified into the different categories (see Sample section).

Statistical Analyses

To test the dimensionality of the HLSAC–German scale, we randomly divided the total data set of the 2018 national German HBSC study into three subsamples of approximately equal size. In the first subsample, the eigenvalues were considered based on an exploratory factor analysis with maximum likelihood extraction using Horn's parallel analysis to obtain initial indications of the scale's dimensionality. In the second subsample, the 1- and the 5-factor structures postulated for the HLASC scale were tested using a confirmatory factor analysis (CFA). In addition, we considered a possible second-order model with 5 factors at the first level and a general factor at the second level. The χ^2-test as well as RMSEA, CFI, TLI, and SRMR were used as fit indices. The model with the best fit was again tested by confirmatory analysis on the third subsample. In addition to mean, standard deviation, skewness, and kurtosis, we also considered item discrimination (correlations between items and HLSAC–German scale as well as between items and subjectively assessed health and physical activity) and item difficulty. Item difficulty was calculated with the equation ((mean – minimum) / (maximum – minimum))*100 and, thus, could reach potential values between 0 and 100.

We then assessed measurement invariance across sex, age groups, and school types using the overall data set for the scale structure identified using this method. For this purpose, we performed a multigroup CFA for ordinal data based on Wu and Estabrook (2016) using the Svetina et al. (2020) script, adding robust standard errors to the script to observe the clustering of data at the class level. The procedure of measurement invariance testing according to Wu and Estabrook (2016) differs from the usual procedure of measurement invariance testing for metric data in that, after checking the configural measurement invariance, the thresholds are equated in the second step, while the equality restrictions for the factor loadings are added only in the third step.

To determine the suitability of the scale in the 11-year-old group, we repeated the CFA with the subsample of this age group. In addition, we repeated the measurement invariance test concerning age without the 11-year-old group and analyzed the number of missing values in the HLSAC–German scale across age groups.

Further construct validity analysis was performed using Pearson's correlations (subjective mental health and physical activity) and the γ-coefficient (consumption of alcohol). The strength of association was classified according to Cohen (1992).

All analyses were performed using SPSS 26 and Mplus 8.6. Cases with missing data were excluded from the analyses (listwise delete). The data on mean differences were supplemented with Cohen's d and η^2 as effect size measures. All confirmatory factor analyses were conducted using the WLSMV estimator with robust standard errors taking clustering at the class level into account and weighting for data by region, school type, sex, and grade level to increase the representativeness of the sample.

Results

Factorial Validity: Dimensionality

The item analysis, carried out with the data of the entire sample, did not reveal anything conspicuous in individual items regarding descriptive parameters, such as distribution (mean value, standard deviation, skewness, and kurtosis), difficulty, or discrimination (Table 1). All 10 items were included in the further analyses to check the dimensionality. The three subsamples formed to test for dimensionality did not differ systematically with respect to sex ($\chi^2(2) = 0.62$, $p = .734$), age group ($\chi^2(4) = 3.43$, $p = .489$), or school type ($\chi^2(6) = 4.00$, $p = .677$).

An exploratory factor analysis (maximum likelihood extraction) was performed with the data from the first

subsample (n = 1,410), considering only the trend of the eigenvalue. The results of Horn's parallel analysis show that one factor should be extracted (empirical eigenvalues of the first two factors in the sample: 4.89, 0.90; random eigenvalues of the first two factors: 1.15, 1.10).

In the second subsample (n = 1,470), the 1- and 5-factor structures postulated by the authors of the HLSAC scale were tested using confirmatory factor analyses. The 1-factor solution ($\chi^2(35) = 185.01$, $p < .001$; RMSEA = .058 [90 % confidence interval CI: .050; .067]; CFI = .980; TLI = .974; SRMR = .026) showed a good model fit. In the 5-factor model ($\chi^2(25) = 122.68$, $p < .001$; RMSEA = .056 [90 % CI: .046; .066]; CFI = .987; TLI = .977; SRMR = .021), misspecification occurred because of an invalid parameter estimate (Heywood case, correlations of factors > 1). The correlations > 1 affected all 5 latent factors. This misspecification could not be resolved even by fixing the corresponding correlations and factor variances, so that overall an interpretation of the data for the 5-factor solution is not permissible. We therefore rejected the 5-factor solution. Testing a second-order model with 5 factors at level 1 and 1 factor at level 2 ($\chi^2(30) = 137.09$, $p < .001$; RMSEA = .053 [90 % CI: .044; .062]; CFI = .986; TLI = .979; SRMR = .022) was not possible because of the same misspecifications (Heywood case, correlations > 1). Again, all latent factors were affected by the invalid correlations, and we were unable to resolve the misspecification by fixing the corresponding parameters. Therefore, a second-order model cannot be identified in the available data. Based on the results of the confirmatory factor analyses, we adopted the 1-factor solution.

The 1-factor structure, determined both on the basis of the eigenvalue trend obtained in the exploratory factor analysis and in the confirmatory factor analyses, was finally tested again using confirmatory analysis on the third subsample (n = 1,467). The one-dimensional model showed a good model fit ($\chi^2(35) = 197.52$, $p < .001$; RMSEA = .061 [90 % CI: .052; .069]; CFI = .981; TLI = .975; SRMR = .026). Standardized factor loadings ranged from .62 to .75 (see Electronic Supplement 2).

In sum, the results of the multistep dimensionality test consistently showed that the 10-item scale HLSAC–German represented 1 factor. The mean value of this health competence factor in the total sample was M = 2.9 (SD = 0.6; range 1.0 to 4.0). The factor explained 43 % of the item variance, comparable to the results obtained for the first subsample. The internal consistency of the factor in the total sample was α = .88, with mean item intercorrelations between r = .30 and .54. All items were left-skewed (skewness < -1) with kurtosis of between -0.42 and 0.37 and reached a sufficiently large discrimination power of between .54 and .68. Item difficulties indicate quite easy items, with item difficulties ranging from between 60 and 75 (see Table 1). Item discrimination concerning correlations with external criteria were relatively small for all 10 items, that is, between $-.23 \le r \le -.12$ for SDQ total problem score and between $-.02 \le r \le .12$ for physical activity (see Table 1).

Factorial Validity: Measurement Invariance

Table 2 shows the results of the measurement invariance tests. The results show full scalar measurement invariance (equating thresholds and factor loadings) with respect to sex. Regarding the age groups and the school forms attended, complete metric measurement invariance (equating the thresholds, releasing the factor loadings) is shown. For the age groups, scalar measurement invariance can be achieved if the equality restrictions are removed for 2 of the 10 items (items 2 and 6). Regarding the school types, removing the equality restrictions for 3 items (items 1, 4, and 8) is necessary to achieve scalar measurement invariance. Thus, there is partial scalar measurement invariance with age groups and school type, and complete scalar measurement invariance with sex.

Factorial Validity: Group Differences

Examination of the measurement invariance of the scale with respect to sex, age groups, and types of school shows that mean comparisons between different groups are possible. Mean comparisons show that girls (M = 3.0, SD = 0.5) have slightly higher health literacy than boys (M = 2.9, SD = 0.6; $t_{3704} = -2.48$; p = .013; d = .08), and that 13-year-olds (M = 3.0, SD = 0.5) have significantly higher health literacy than 11-year-olds (M = 2.9, SD = 0.7; $F_{2,\ 3613} = 10.56$; $p < .001$; $\eta^2 = .01$), although in each case the effects were very small. Learners at high schools (M = 3.1, SD = 0.5; $p < .008$) show the highest expression of health literacy compared to students from all other school types, and learners at lower secondary schools (M = 2.7, SD = 0.6; $p < .008$) the lowest. The effect size for school form differences can be described as medium ($\eta^2 = .05$). All group-specific means and mean comparisons are presented in Electronic Supplement 3.

Suitability of the Scale for 11-Year-Olds

In order to verify the suitability of the scale for 11-year-olds, we repeated the test of the determined single-factor structure on the subsample of this age group. Of n = 1,387 11-year-olds surveyed, complete data on health literacy were available from n = 1,045. The unidimensional model

Table 2. Results of measurement invariance tests concerning sex, age, and type of school attended

	χ^2 model fit	χ^2 difference test	RMSEA (90 % CI)	CFI	TLI	SRMR
Sex (n = 3,726, male: n = 1,749, female: n = 1,977)						
Configural invariance	χ^2 (70) = 708.76; p < .001		.070 (.065; .075)	.972	.964	.028
Metric: Equal thresholds	χ^2 (80) = 709.01; p < .001	χ^2 (10) = 11.32; p = .333	.065 (.061; .069)	.973	.969	.028
Scalar: Equal thresholds and factor loadings	χ^2 (89) = 626.32; p < .001	χ^2 (9) = 6,75; p = .663	.057 (.053; .061)	.977	.976	.028
Age groups (n = 3,697, 11-year-olds: n = 1,045; 13-year-olds: n = 1,225; 15-year-olds: n = 1,427)						
Configural invariance	χ^2 (105) = 774.58; p < .001		.072 (.067; .077)	.971	.963	.030
Metric: Equal thresholds	χ^2 (125) = 778.16; p < .001	χ^2 (20) = 16.86; p = .662	.065 (.061; .070)	.972	.969	.031
Scalar: Equal thresholds and factor loadings	χ^2 (143) = 732.90; p < .001	χ^2 (18) = 35.51; p = .008	.058 (.054; .062)	.974	.976	.031
Scalar without factor loadig-restrictions on items 2 and 6	χ^2 (139) = 730.49; p < .001	χ^2 (14) = 18.50; p = .185	.059 (.055; .063)	.974	.975	.031
Type of school (n = 3,726, Lower secondary schools: n = 324; Intermediate secondary schools: n = 677; Grammar schools: n = 1,681; Mixed school type: n = 1,044)						
Configural invariance	χ^2 (140) = 722.45; p < .001		.067 (.062; .072)	.972	.964	.031
Metric: Equal thresholds	χ^2 (170) = 714.61; p < .001	χ^2 (30) = 25.69; p = .691	.059 (.054; .063)	.974	.972	.031
Scalar: Equal thresholds and factor loadings	χ^2 (197) = 661.53; p < .001	χ^2 (27) = 40,14; p = .050	.050 (.046; .055)	.978	.979	.032
Scalar without factor loadig-restrictions on items 1, 4, 8	χ^2 (188) = 672.57; p < .001	χ^2 (18) = 17.20; p = .510	.053 (.048; .057)	.977	.978	.031

indicated an acceptable fit of the model to the data ($\chi^2(35)$ = 362.48, p < .001; RMSEA = .095 [90 % CI: .086; .104]; CFI = .960; TLI = .948; SRMR = .033).

To test whether the limitations of measurement invariance for age (partial scalar measurement invariance) might be related to problems with the usability of the scale in the 11-year-old group, we repeated measurement invariance testing for age without the 11-year-olds. The results were identical to the test of measurement invariance in the total sample (partial scalar measurement invariance; see Electronic Supplement 4 for results). We observed no specific problems in the age group of 11-year-olds.

A further check of the suitability of the scale for 11-year-olds was based on an analysis of missing values. Younger respondents had on average more missing values than older participants (missing values per person: 11-year-olds M = 1.49, SD = 3.24; 13-year-olds M = 0.61, SD = 2.09; 15-year-olds M = 0.27, SD = 1.44). All three age groups differed statistically significantly from each other ($p \leq .001$). Analyses of variance using Scheffé posthoc analyses showed that this affects all items (the only exceptions being items 1 and 2, where 13- and 15-year-olds have a comparable number of missing values; see Electronic Supplement 5). Thus, younger respondents can generally be expected to have more missing data than older respondents. There are no specific problems with particular items. In sum, the results show that the scale HLSAC–German is suitable for 11-year-olds. However, some general problems in answering the items can be expected, resulting in more missing values.

Further Assessment of Construct Validity: Associations with Risk and Health Behaviors

The mean health literacy score correlated moderately with the SDQ total problem score (r = -.24; p < .001) and slightly with the days respondents were physically active for at least 60 minutes (r = .11; p < .001). However, there was no significant association between health literacy and the 30-day prevalence of alcohol consumption (γ = -.02, p = .446). Table 1 shows the item-level correlations between health literacy and the subjective assessment of mental health (SDQ total problem score) and physical activity.

Discussion

The present study examines the psychometric properties of the HLSAC–German scale. For this purpose, we examined the dimensionality, the measurement invariance with respect to sex, age, and type of school attended as well as the correlations with various indicators of health and health behavior. In addition, we analyzed whether the scale was also suitable for use in 11-year-olds, since the original scale was validated only in 13- and 15-year-olds. The results of exploratory and confirmatory factor analyses consistently demonstrated the unidimensionality of the scale. The scale showed complete scalar measurement invariance for sex and partial scalar measurement invariance for age and type of school attended, showing that mean comparisons across different groups are indeed possible. In addition to these findings on factorial validity, there were further indications of construct validity in the form of correlations with risk and health behaviors. As expected, the scale correlated negatively with subjectively assessed mental health problems and positively with physical activity as a health behavior, with the correlations indicating small to medium effect sizes. However, expected negative correlations with alcohol consumption did not emerge. Despite this limitation, the HLSAC–German scale can be considered suitable for measuring health literacy in childhood and adolescence based on the findings presented.

Regarding the scale structure in 11-year-olds, the fit indices are ambivalent. While the CFI and TLI values indicate an acceptable fit, the RMSEA value indicates an unacceptable fit and the SRMR value indicates a good fit (Schermelleh-Engel et al., 2003). However, since two conceptually different indices (Schermelleh-Engel et al., 2003) – the SRMR and the CFI – indicate at least an acceptable fit, it can be assumed that the scale is also unidimensional in 11-year-olds. Still, we recommend checking the dimensionality in new samples, especially when they include participants from the youngest age group. The examination of the measurement invariance also points to the possible use of the scale in the 11-year-old age group. However, analyses of the missing values show that some 11-year-olds had difficulties answering the items, meaning a higher proportion of nonresponders is expected in this age group. Thus, one should interpret the findings on the health literacy of 11-year-olds with the HLSAC–German scale with caution.

The unidimensionality of the HLSAC–German scale found in the total sample is consistent with other findings on international versions of the HLSAC questionnaire (Bonde et al., 2022; Mazur et al., 2019; Velasco et al., 2021). One advantage of measuring health literacy with an overarching unidimensional factor is that one can quickly obtain an overview of health literacy. At the same time, this kind of health-literacy measurement does not allow for differentiated statements about the multidimensional construct, thus requiring other measurement instruments for specific uses (Guo et al., 2018; Ormshaw et al., 2013). As an economical method, the HLSAC–German scale is, therefore, particularly suitable for thematically broad surveys that assess health literacy and other health-related indicators in childhood and adolescence. The availability of a revised German-language version of the HLSAC scale makes it possible to compare the results of health-literacy surveys in childhood and adolescence in Germany with international findings obtained using different language versions of the HLSAC scale.

Of the examined correlations of the HLSAC–German scale with indicators of health and health behavior, the largest (albeit overall only moderate) associations were found for the subjective assessment of one's mental health status. It should be noted that both assessments could be based on comparably optimistic or pessimistic reporting tendencies, which could limit the significance of the correlations as evidence of validity (Paakkari et al., 2020). This underscores the importance of using further measures to examine the construct validity of the scale. Positive associations with physical activity emerged as expected, although only slightly. However, there was no significant correlation with alcohol consumption. Such an association was expected, as it has been consistently reported across different conceptions of health literacy in a range of studies (Fleary et al., 2018). The low levels of alcohol consumption in the overall sample should be taken into account when considering this result. Alcohol consumption is a culturally dependent risk behavior, and international comparative studies indicate that alcohol consumption by adolescents in Germany may be lower than in other countries (de Looze et al., 2015; Leal-López et al., 2021; Patil et al., 2014). Current research lacks findings from Germany, in particular on the relationship between alcohol consumption and health literacy (Fleary et al., 2018). We therefore cannot give a clear answer as to whether alcohol consumption in representative German child and adolescent samples, such as the present one, is suitable as a validation criterion. To further substantiate the validity of the scale, it would be desirable to carry out additional investigations into construct validity based on other instruments for measuring health literacy and particularly on external criteria not collected using self-reports. Questions about the predictive validity of both the HLSAC scale and the German version HLSAC–German are still open and should be investigated in longitudinal studies.

The underlying definition of health literacy is based on a broad set of action and regulation competencies (Paakkari

& Paakkari, 2016), and the items refer to subjective competence beliefs, which are often understood as being closely related to or part of health literacy (Bröder & Carvalho, 2019; Nutbeam, 1998; Okan et al., 2015; Paakkari & Paakkari, 2012). However, the scale does not address the significant question of health-literacy development, which is particularly important in childhood and adolescence (Bröder & Carvalho, 2019; Fleary et al., 2018; Guo et al., 2018; Okan et al., 2015). At the same time, findings on the expression of health literacy in relation to socioeconomic status (Caldwell & Melton, 2020; Fleary et al., 2018) or the educational background of adolescents (Quenzel, 2018; Quenzel et al., 2015) underscore the importance of the external promotion of health literacy. Both the analysis of health literacy development and the monitoring of the success of possible promotion measures for health-related literacy enhancement require change-sensitive measurement instruments. The change sensitivity of the HLSAC–German scale should be verified in future studies.

Limitations

The underlying data stem from the HBSC study, which includes 11-, 13-, and 15-year-olds. Thus, we can make no statements about the psychometric properties of the scale in younger or older age groups.

The present study examined the measurement invariance of the scale concerning sex, age, and types of school attended. This corresponds to key characteristics often used to analyze group differences in health-literacy research. In addition, studies also show other group differences, such as those related to ethnic or educational family background (Caldwell & Melton, 2020; Fleary et al., 2018). The inclusion of such aspects is particularly significant for the study of health inequalities. Testing the measurement invariance of the HLSAC–German scale concerning additional group characteristics should thus be conducted in future studies.

Physical activity and alcohol consumption, which were analyzed to investigate correlations between risk and health behaviors, were surveyed using only a single item. Future studies should aim to use a methodically more comprehensive survey of suitable aspects to investigate convergent validity. Overall, the scale must be further examined regarding its criterion-related validity (especially prognostic validity and sensitivity to change) and other aspects of construct validity (convergent validity in the sense of correlations with other measurement methods).

Beyond these limitations, though, the large sample size and the multistep procedure for testing the psychometric properties of the scale on the basis of subsamples represent methodological strengths of the present study.

Conclusion

The present study examines the dimensionality, measurement invariance, and construct validity of the HLSAC–German 10-item scale for measuring health literacy in childhood and adolescence. The analyses show that the scale is a suitable way of economically measuring a general factor of health literacy in 11-, 13-, and 15-year-olds. In the 11-year-old age group, we found a higher proportion of nonresponders, so that the dimensionality should be further examined. However, our study suggests that the use of the scale in this age group is generally appropriate. This represents an expansion of the German-language version. The results for HLSAC–German indicate a one-dimensional, fully (regarding sex) or partially (regarding age groups and type of school attended) scalar invariant scale, making mean comparisons possible. Associations with the subjective assessment of mental health and physical activity as a behavioral indicator indicate the construct validity of the scale. Further analyses with, for example, objectively measured external criteria as well as on the change sensitivity of the scale, are necessary.

Electronic Supplementary Material

The electronic supplementary material is available with the online version of the article at https://doi.org/10.1026/0012-9124/a000296

ESM 1. German-language items of the scale HLSAC–German.

ESM 2. 1-factor model (CFA) in the third subsample (n = 1,467).

ESM 3. Group-specific means and mean comparisons in the total sample (N = 4,347).

ESM 4. Results of measurement invariance test concerning age, excluding the group of 11-year-olds (n = 2,652).

ESM 5. Number of missing values at the item level separated by age group in the total sample (N = 4,347).

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Publication Ethics

The underlying survey was conducted in compliance with the European General Data Protection Regulation (DSGVO) and the German Federal Data Protection Act (BDSG) and was approved in all German states by the respective Ministries of Education and Cultural Affairs. The participation of all surveyed students took place after written consent had been obtained from either the students or their legal guardians after receiving comprehensive information on the content and objectives of the survey (informed active consent).

Authorship

All authors were involved in the conception of the article. Saskia Fischer performed the calculations and wrote the article. Kevin Dadaczynski provided significant support in the theoretical embedding. Kevin Dadaczynski, Gorden Sudeck, Katharina Rathmann, and Ludwig Bilz supplemented earlier drafts of the article and contributed to the further development of the manuscript. Olli Paakkari and Leena Paakkari are the authors of the original Finnish scale and added information on further scale development, as well as commenting on earlier versions of the manuscript. Ludwig Bilz initiated and coordinated the team of authors.

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