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Differential associations of health literacy with Austrian adolescents' tobacco and alcohol use

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ABSTRACT

Objectives: Tobacco use and alcohol use have their origin in adolescence, and risky use of these substances is amongst the leading preventable causes of morbidity and mortality. Health literacy (HL) encompasses the skills that are decisive to make appropriate health decisions in this context. Given the paucity of evidence on the link between HL and adolescents' health behaviors, the present study examined overall HL and different components of HL and their associations with smoking and alcohol use among 13 to 17-year-old Austrian students.

Study design: Data were obtained from a national survey carried out in Austria (N = 4219; 56% females) as part of the Health Behaviour in School-aged Children: World Health Organization (WHO) collaborative cross-national study.

Methods: We tested two structural equation models, one including the overall HL scale as the predictor and one with the three subscales of HL 'finding,' 'understanding and appraising,' and 'applying' health-related information as predictors of smoking and alcohol use.

Results: Although overall HL was related to all indicators of adolescents' smoking and drinking, the three HL components had differential effects on these behaviors. The easier it was for the participants to 'understand and appraise' and 'apply' health-related information, the less frequently they had smoked and drunk alcohol and the less was the amount of alcohol they had consumed. Contrarily, the easier it was for the participants to 'find' information, the more they had smoked and drunk alcohol.

Conclusions: Our results indicate that availability of health-related information may be insufficient on its own to prevent or reduce risky substance use. This is of particular importance for the development and improvement of primary prevention programs targeting adolescent populations.

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Introduction

Tobacco use and harmful alcohol use have been identified as two of the four health behaviors most strongly associated with and causally linked to non-communicable diseases. In 2016, more than three million deaths, or one in 20 global deaths, were attributable to alcohol consumption,[1] and around six million deaths were attributable to the consequences of tobacco use.[2]

Tobacco use and alcohol use have their origin in adolescence and tend to peak between the ages of 18 and 25 years.[3,4] The results from the European School Survey Project on Alcohol and Other Drugs (ESPAD) indicate that Austria has relatively high alcohol use and smoking rates in adolescents compared with other European countries.[5] While the prevalence of lifetime alcohol use (Austria: 88%) is close to the European average (80%), Austrian 16-year-olds have a considerably higher use in the past 30 days (Austria: 68%; European average: 48%) and the highest alcohol intoxication rate during the last 30 days of all European countries included in the ESPAD survey (21% vs. 13%).[5] Data on 15-year-olds from the Health Behaviour in School-aged Children (HBSC) study indicate a similar pattern: in its most recent survey, Austria was in the top quartile of 43 European and North American countries with regard to the prevalence of alcohol use at least once a week.[6] The smoking prevalence amongst Austrian adolescents is closer to but still more than the European average: 14% of Austrian 15-year-olds smoke at least once a week (European average: 12%),[5] and 28% of Austrian 16-year-olds have smoked during the last 30 days (European average: 21%).[6]

In this context, it needs to be considered that Austria came last in the European Tobacco Control Scale 2016,[7] which quantifies the implementation of tobacco control policy at the country level. The leading countries in this survey show a considerably lower smoking prevalence amongst adolescents. For example, Iceland and Norway ranked among the top five, and both countries show smoking rates of less than 5% amongst 15-year-olds.[6]

Internationally, the severe consequences of risky substance use in young people have led to a range of prevention and intervention programs and campaigns, with the aim to delay the age of onset and to reduce the frequency and amount of substance use among adolescents.[8] Besides community policies (e.g., smoke- and tobacco-free zones) and access to quit smoking resources, antitobacco media campaigns and educational initiatives have been recommended as best practices regarding tobacco prevention.[9,10] Mass media campaigns have shown small yet positive effects in reducing youth tobacco use[11] and in preventing the uptake of smoking in young people.[12] However, the success of such interventions is hampered by pervasive marketing (e.g., by the tobacco industry). In addition, the application of multiple interventions and long-term investments are necessary to sustain positive campaign outcomes. This particularly applies to habitual or ongoing behavior such as alcohol use and smoking.[13] Research on educational programs targeted at adolescents (e.g., in-school or after-school programs) has yielded mixed results.[14,15] Particularly, the mere provision of information about harmful consequences of substance use does not seem to be sufficient on its own to prevent or reduce substance use.[8,16]

A more general framework, which goes beyond the mere availability of information about risky health behaviors and their consequences, is the concept of health literacy (HL). HL 'is linked to literacy and entails people's knowledge, motivation, and competences to access, understand, appraise, and apply health information to make judgments and take decisions in everyday life concerning health care, disease prevention, and health promotion to maintain or improve quality of life during the life course.'[17] HL has been shown to be associated with various health behaviors and health-related outcomes in general[18,19] and with smoking in particular.[20–22] However, studies focusing on the effect of HL on alcohol use in adult samples yielded inconsistent results.[23–27]

The HL concept has gained importance on the European health agenda and is now being used also within the public health context.[28] However, despite the growing attention for the concept, scientific data on the status of HL in Europe remain scarce. To address this limitation, a recent survey compared HL in populations across eight European countries.[29] The results indicate that at least one in ten respondents showed insufficient HL. Austria was the country with the second lowest general HL (after Bulgaria): 18% of participants exhibited inadequate and 38% exhibited problematic general HL.

Very few studies have investigated the link between HL and health behaviors in adolescents so far, particularly outside of the United States.[30,31] Existing evidence on HL suggests that up to 50% of adolescents have low HL and that lower HL scores are associated with adverse health behaviors such as smoking.[32] In addition, international evidence from constructs related to HL, such as smoking media literacy,[33] interactive HL (interest in learning about health, understanding what they hear about health, trying to follow what is taught about health),[34] or health knowledge,[35] indicates that HL might play an important role in moderating current smoking behavior and susceptibility for future smoking in adolescents.

For adolescents' alcohol use, the limited evidence on associations with HL is contradictory, similar to that for adults. Some studies revealed that alcohol use is positively correlated with higher HL amongst teens[36] and young adults.[37] One potential explanation of this association relates to media effects: adolescents with high HL may be subjected to greater advertising influences than those with low HL who may be less able to read and/or understand the messages and thus are less likely to be influenced by them.[36] However, other investigations contradict these results in that young adults with higher media literacy were found to less likely use alcohol.[38]

To date, the associations between HL and adolescents' smoking and alcohol use behaviors remain unclear. Understanding how HL is associated with adolescents' substance use behaviors could provide important guidance for the development and improvement of primary prevention programs. To address this research gap, the present study aimed to examine the association of overall HL with smoking and alcohol use in Austrian adolescents, a population with relatively high alcohol use and smoking rates.[5,6] Although it can be assumed that HL is not a unidimensional concept, there is no consensus about the conceptual dimensions of HL. A systematic review of existing definitions and concepts of HL identified four main

dimensions of HL: competencies related to accessing, understanding, appraising, and applying health information.[39] Based on this conceptual model of HL, a measure of HL—the European Health Literacy Survey Questionnaire (HLS-EU-Q)—was derived. A short version of this instrument was used to measure HL in the present study, which enabled investigating for the first time the differential associations of finding, understanding, appraising, and applying health-related information with adolescents' smoking and alcohol use.

Methods

Data for this cross-sectional investigation were obtained from a national survey carried out in 2013/2014 in Austria as part of the HBSC: WHO collaborative cross-national study. The survey is conducted every four years in currently 43 European and North American countries. The overall objective is to systematically and periodically monitor adolescents' health and health behaviors. The HBSC study uses a self-report questionnaire, which is developed and validated in a continuous process involving all member countries.

Cluster probability sampling (random) of school classes was carried out. Sampling of schools (proportional to size) was carried out where lists of classes were not available, followed by sampling of classes within schools. The aim was to ensure that the sample was nationally representative for the age-groups of 11-, 13-, and 15-year-olds attending school in each country and region. At least 95% of children within these age-groups have been included in the sample frame. Data collection was anonymous, and standardized information about the study was provided to parents and students with the invitation to participate. In addition to the students' consent, parents had to give consent to their children taking part. Teachers administered the survey either as a paper-and-pencil (18% of schools) or online questionnaire (82% of schools) to pupils aged 11, 13, 15, and 17 years.

The total sample size was $N = 5614$ (45% boys, 55% girls; 25% 11-year-olds, 23% 13-year-olds, 31% 15-year-olds, and 21% 17-year-olds), representative by age, sex, federal state, and type of school of the total Austrian pupil population.

Measures

HL was measured using a 16-item scale based on the instrument used in the 'European Health Literacy Survey.'[40] The shorter version of the original 47-item instrument was psychometrically tested for 15-year-old adolescents in Austria.[41] To be applicable to a younger target population within the scope of the HBSC, the wording of items and answering categories have been simplified. For each item referring either to finding, understanding, appraising, or applying health-related information, the respondents rated the perceived difficulty of a given task on a three-category scale ('easy,' 'difficult,' 'don't know'). After piloting the instrument with adolescents between the age of 11 and 18 years, a minimum age of 13 years was set for the HL questionnaire. For this reason, only data from pupils aged 13 years and older were included in the present analyses.

Smoking and drinking behaviors were measured by asking how often participants had been smoking and drinking alcohol, respectively, during the past 30 days, and in their lifetime, with response categories ranging from 'never' to '30 times or more.' Recent and lifetime drunkenness was assessed in a similar way, with response categories ranging from 'never' to 'more than 10 times.' In addition, 15- and 17-year-olds were asked about their typical quantity of alcohol consumption on occasions when they were drinking, with response categories extending from 'none' to '5 drinks or more.'

Analytical approach

All analyses were conducted using the software Mplus 7.3.[42] In the first step, confirmatory factor analyses (CFAs) with ordered-categorical indicators were conducted to examine the construct validity of (1) the overall HL scale and (2) the HL scale divided into the subscales 'finding,' 'understanding,' 'appraising,' and 'applying' health-related information. However, the results of the four-factor solution estimated a factor correlation greater than 1 [$\beta = 1.06$, Standard error (SE) $= 0.03$, $P < .001$] between the subscales 'understanding' and 'appraising' of health-related information, which indicates estimation problems. This is why we decided to combine the two subscales and proceeded with a three-factor solution that subdivided the HL scale into the subscales 'finding,' 'understanding and appraising,' and 'applying' health-related information. The goodness of fit of the models was evaluated using the following indices: root mean square error of approximation (RMSEA), the comparative fit index (CFI), and the Tucker-Lewis index (TLI) in addition to the Chi-squared test of model fit value and its associated degrees of freedom. We used traditional cutoff scores indicative of excellent and adequate fit to the data, respectively: (1) CFI and TLI ≥ 0.95 and ≥ 0.90 and (2) RMSEA ≤ 0.06 and ≤ 0.08.[43]

In the second step, we tested two structural equation models (SEMs), one including the overall HL scale as the predictor and one with the three subscales of HL as predictors. For both models, indicators of smoking and drinking were the dependent variables. Model parameters were estimated via the robust weighted least squares estimator. As results, we provide standardized coefficients.

We calculated convergent and discriminant validity of both the one-factor-solution for the overall HL scale and the three-factor solution that subdivided the HL scale into three subscales using the Fornell–Larcker criterion.[44] According to this criterion, the convergent validity of the measurement model can be assessed by average variance extracted (AVE) and composite reliability (CR). According to the authors, AVE values more than 0.7 are considered very good, whereas the level of 0.5 is acceptable. CR is a less biased estimate of reliability than Cronbach's alpha, and the acceptable value of CR is 0.7 and above. Furthermore, if the AVE value for each construct is greater than its shared variance with any other construct, discriminant validity is supported. The analyses indicated an AVE $= 0.386$ and a CR $= 0.903$ for the one-factor solution. The results for the three-factor solution were as follows: 'finding,' AVE $= 0.445$, CR $= 0.826$; 'understanding and appraising,' AVE $= 0.390$, CR $= 0.835$; and 'applying,' AVE $= 0.730$, CR $= 0.843$. According to the criterion of the AVE value >0.50, only applying in the three-factor solution shows an acceptable convergent validity. However, Fornell and

Larcker[44] indicate that if the AVE value is less than 0.5, but the CR value is higher than 0.6, the convergent validity of the construct is still adequate. According to the Fornell–Larcker[44] testing system, discriminant validity can be assessed by comparing the amount of the variance captured by the construct (AVE) and the shared variance with other constructs. The shared variance results were as follows: 'finding' with 'understanding and appraising' = $0.838^2 = 0.702$; 'finding' with 'applying' = $0.536^2 = 0.287$; and 'understanding and appraising' with 'applying' = $0.690^2 = 0.476$. Our analyses indicate a lack of discriminant validity between 'finding' and 'understanding and appraising' and between 'understanding and appraising' and 'applying,' calling into question that these dimensions are theoretically distinct.

Moreover, we assessed the common method bias following the procedure described by Liang et al,[45] that is, we controlled for the effects of a common latent method factor creating a specific method factor that comprises all items used in the different measurement models and calculating the amount of each item's variance explained by the method factor. Our analysis shows that the indicators' substantive constructs all explain a substantially greater amount of the indicators' variances than the method factor (see Table 1),[46] meaning that common method bias appears to be of no particular concern. However, owing to our research design, we cannot entirely rule out the possibility of bias and thus encourage readers to bear this limitation in mind.

Results

Adolescents' smoking and drinking behaviors

Approximately one-third (30.4%) of participants who had ever smoked ($n = 1432$) were 14 years or younger when they smoked cigarettes for the first time, and 14.8% had smoked at least 3–5 times during the last 30 days. In comparison, 53.3% of participants who had ever consumed alcohol ($n = 2630$) indicated that they were 14 years or younger when they first drank alcohol, and 21.1% were not older than 14 years when they were drunk for the first time. On occasions when they were drinking, 27.9% of participants who had ever consumed alcohol indicated that they usually drank five or more alcoholic drinks, and 28.7% had been drunk at least 3–5 times in their lifetimes. Descriptive results for the smoking and drinking behaviors of all participants and separately for boys and girls are depicted in Table 2.

Associations between overall HL, smoking, and drinking

The CFA testing a one-factor solution for the overall HL scale resulted in a good model fit, Chi-squared(104) = 1024.48, $P < .001$, RMSEA = 0.05, CFI = 0.91, and TLI = 0.90. In addition, the SEM testing relations between HL and indicators of smoking and drinking, including age and gender as covariates, fitted the data well, Chi-squared(241) = 1476.53, $P < .001$, RMSEA = 0.03, CFI = 0.99, and TLI = 0.98. The results show that the more difficult it is for the participants to find, understand and appraise, and apply health-related information, the more cigarettes they have smoked in their entire lives ($\beta = 0.12$, $P < .001$) and in the last 30 days ($\beta = 0.15$, $P < .001$). Relations between HL and alcohol consumption show a similar pattern. The lower the participants' HL, the more frequent was their alcohol consumption (lifetime: $\beta = 0.03$, $P < .05$; last 30 days: $\beta = 0.07$, $P < .001$). Participants with lower HL also consumed a larger amount of alcoholic beverages on occasions when they were drinking ($\beta = 0.04$, $P < .05$) and had been drunk more often in their lifetime ($\beta = 0.08$, $P < .001$) and during the last 30 days ($\beta = 0.07$, $P < .01$).

The participants' age was significantly related to all indicators of smoking and drinking. The older the participants, the higher was their consumption of tobacco and alcohol and their frequency of being drunk during their lifetime (tobacco: $\beta = 0.61$, $P < .001$, alcohol: $\beta = 0.75$, $P < .001$, being drunk: $\beta = 0.73$, $P < .001$) and during the last 30 days (tobacco: $\beta = 0.55$, $P < .001$, alcohol: $\beta = 0.68$, $P < .001$, being drunk: $\beta = 0.60$, $P < .001$). Older participants also consumed a higher amount of alcoholic beverages per drinking occasion ($\beta = 0.59$, $P < .001$).

Table 1 – Latent method factor ($N = 5718$).

Construct	Substantive factor loading (R1)	$R1^2$	Method factor loading (R2)	$R2^2$
Finding	0.523	0.274	0.230	0.053
	0.606	0.367	0.008	0.000
	0.668	0.446	0.035	0.001
	0.693	0.480	0.119	0.014
	0.815	0.664	0.088	0.008
	0.671	0.450	0.115	0.013
Understanding	0.545	0.297	−0.002	0.000
	0.600	0.360	−0.058	0.003
	0.646	0.417	0.002	0.000
	0.616	0.379	0.143	0.020
	0.611	0.373	0.179	0.032
	0.639	0.408	0.120	0.014
	0.706	0.498	0.087	0.008
	0.747	0.558	−0.010	0.000
Applying	0.913	0.834	0.108	0.012
	0.754	0.569	0.230	0.053

Table 2 – Frequency of smoking and drinking, number of alcoholic drinks per drinking occasion, and frequency of drunkenness for all participants, girls and boys.

Frequency	Smoking (lifetime)			Smoking (last 30 days)		
	Total[a] ($N = 4127$)	Girls ($n = 2316$)	Boys ($n = 1804$)	Total[a] ($N = 4029$)	Girls ($n = 2282$)	Boys ($n = 1741$)
Never	65.3	64.1	67.0	79.4	78.7	80.5
1–2 times	9.9	9.0	9.0	5.8	5.9	5.6
3–5 times	4.5	4.9	4.0	3.0	3.4	2.6
6–9 times	2.7	2.7	2.8	1.6	2.0	1.1
10–19 times	2.7	3.2	2.1	2.2	2.5	1.8
20–29 times	2.5	2.7	2.3	2.8	2.7	2.9
30 times or more	13.2	13.4	12.8	5.2	4.9	5.5
Frequency	**Drinking (lifetime)**			**Drinking (last 30 days)**		
	Total[a] ($N = 4116$)	Girls ($n = 2312$)	Boys ($n = 1798$)	Total[a] ($N = 4021$)	Girls ($n = 2268$)	Boys ($n = 1747$)
Never	36.1	35.1	37.3	51.9	50.4	54.0
1–2 times	13.7	13.6	13.8	22.9	25.2	19.9
3–5 times	7.7	7.4	8.2	13.3	14.2	12.1
6–9 times	6.5	7.2	5.7	7.3	7.0	7.7
10–19 times	8.2	8.0	8.5	3.0	2.2	3.9
20–29 times	6.0	7.5	4.1	0.5	0.3	0.7
30 times or more	21.8	21.2	22.4	1.2	0.7	1.5
Frequency	**Drunkenness (lifetime)**			**Drunkenness (last 30 days)**		
	Total[a] ($N = 4146$)	Girls ($n = 2330$)	Boys ($n = 1811$)	Total[a] ($N = 3982$)	Girls ($n = 2238$)	Boys ($n = 1737$)
Never	58.1	58.9	57.1	80.7	82.4	78.7
1–2 times	13.1	13.9	12.3	11.9	12.0	11.8
3–5 times	13.1	14.1	11.8	5.3	4.4	6.6
6–9 times	7.9	7.6	8.3	1.5	1.0	2.0
More than 10 times	7.7	5.5	10.5	0.6	0.1	0.9
Number of drinks	**Typical number of alcoholic drinks consumed during a drinking occasion[b]**					
	Total[a] ($N = 2695$)		Girls ($n = 1606$)		Boys ($n = 1085$)	
Never	26.4		27.3		25.2	
Less than one	13.5		12.2		15.5	
1 drink	6.5		6.0		7.2	
2 drinks	7.3		7.6		6.9	
3 drinks	9.1		10.3		7.2	
4 drinks	9.3		10.3		7.9	
5 or more	27.9		26.3		30.1	

[a] Overall, seven participants did not indicate their gender; thus, the total N for each indicator of smoking and drinking may exceed the sum of girls and boys.
[b] This item was only administered to 15 to 17-year-olds.

The participants' gender was only related to indicators of drinking but not smoking. Male participants reported a higher frequency of drinking and being drunk in their lifetime (drinking: $\beta = -0.04$, $P = .001$, being drunk: $\beta = -0.10$, $P < .001$) and during the last 30 days (drinking: $\beta = -0.05$, $P = .001$, being drunk: $\beta = -0.10$, $P < .001$).

Associations between different components of HL, smoking, and drinking

The CFA proposing a three-factor solution that subdivided the HL scale into the subscales 'finding,' 'understanding and appraising,' and 'applying' health-related information showed a better model fit compared with the one-factor solution, Chi-squared(101) = 596.04, $P < .001$, RMSEA = 0.03, CFI = 0.95, and TLI = 0.94. The SEM including the three subscales as independent variables, indicators of smoking and drinking as the dependent variables, and age and gender as covariates also obtained a better model fit than the model including the overall HL scale, Chi-squared(224) = 997.14, $P < .001$, RMSEA = 0.03, CFI = 0.99, and TLI = 0.99. The results are depicted in Fig. 1.

The factor 'finding' was negatively related to all indicators of smoking and drinking, except for drinking frequency (lifetime), that is, the easier it was for the participants to find health-related information, the more they had smoked and drunk. Contrarily, the factor 'understanding and appraising' was positively related to most indicators of smoking and drinking. Participants who found it easier to understand and appraise health-related information had smoked fewer cigarettes, had drunk less alcohol during the last 30 days, and had been drunk less frequently. In addition, the factor 'applying' was positively related to the participants' drinking behavior. The easier it was for them to

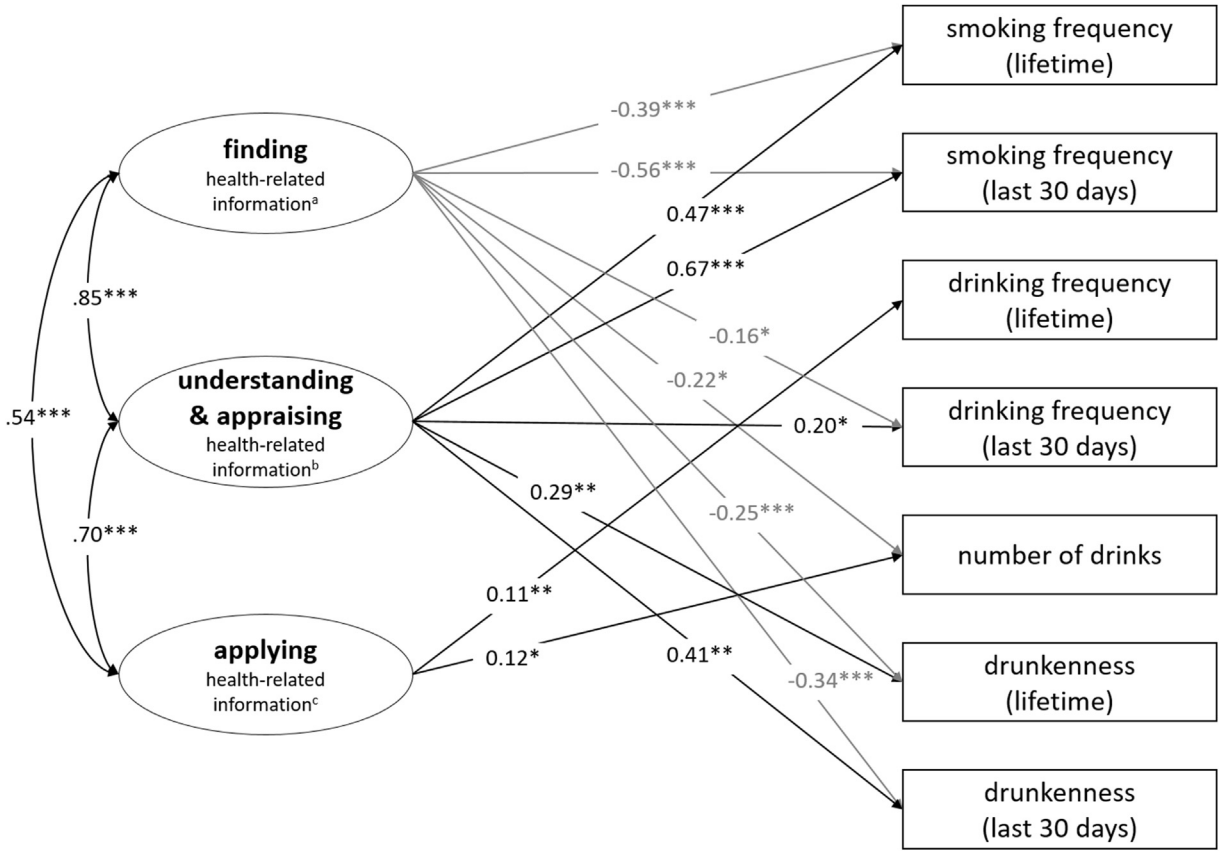

Fig. 1 – Results of the structural model including the three HL subscales as independent variables and indicators of smoking and drinking as the dependent variables. Note: SEM analyses for smoking and drinking (dependent variables) were combined to achieve a more concise representation of the results. The figure depicts the structural model of the SEM (without the measurement model). Standardized regression coefficients are reported, and non-significant paths are not shown. Covariates: age, gender. *P ≤ .05; **P ≤ .01; ***P ≤ .001. [a]This HL scale includes the items Q.2, Q.4, Q18, Q.28, Q.31, and Q.33 of the HLS-EU-47 questionnaire (see [40], p. 2–3, items were scored as 0 = 'easy' or 1 = 'difficult'). [b]This HL scale includes the items Q.5, Q.8, Q.11, Q.21, Q.23, Q.37, Q.39, and Q.43 of the HLS-EU-47 questionnaire (see [40], p. 2–3; items were scored as 0 = 'easy' or 1 = 'difficult'). [c]This HL scale includes the items Q.13 and Q.16 of the HLS-EU-47 questionnaire (see [40], p. 2–3; items were scored as 0 = 'easy' or 1 = 'difficult'). HL, health literacy; HLS-EU, European Health Literacy Survey; SEM, structural equation model.

apply health-related information, the less frequently they had drunk alcohol during their lifetime and the less was the amount of alcohol they had consumed per drinking occasion.

Discussion

The aim of this study was to investigate overall HL and different components of HL and their associations with adolescents' smoking and alcohol use behaviors. The findings support prior results in that overall HL was associated with adolescents' smoking behavior.[32] However, these effects were small for different indicators of smoking and even smaller for drinking behaviors. The latter result reflects the contradictory evidence on the association of alcohol use with HL.[36–38]

It has been suggested that the most frequently used HL measures are overly simplistic and do not adequately reflect the diverse skills that are necessary to navigate healthcare and health promotion settings effectively.[32,47] A conceptual model of HL, developed within the European Health Literacy Project (HLS-EU), contains twelve dimensions referring to the knowledge, motivation, and competencies of accessing, understanding, appraising, and applying health-related information within the healthcare, disease prevention, and health promotion setting, respectively.[39] This indicates that HL is not a unidimensional concept but rather consists of different components, which may have differential effects on health behaviors. Our results support this assumption in that the three-factor solution, which subdivided HL into the subscales 'finding,' 'understanding and appraising,' and 'applying' health-related information, had a better model fit as compared with the one-factor solution. In addition, the three HL components had differential effects on adolescents' substance use behaviors.

The current investigation evidenced that finding health-related information easily is associated with a higher frequency of smoking and drinking, a larger amount of alcoholic drinks consumed per drinking occasion, and a higher frequency of being drunk. This finding is consistent with a

study indicating that young male 'at-risk' substance users (defined as those with ≥21 drinks per week, daily smoking, and/or cannabis use at least twice weekly) were more likely to be well informed about the risks of substance use, compared with not-at-risk users and abstainers.[37] The causal pathway of this association remains unclear. It is possible that those who use substances more frequently are more interested in and/or more concerned about negative consequences related to their substance use and thus are more likely to search for substance-related information.[37] In contrast, those who are better informed about a substance may be more likely to use it, which is potentially related to media effects, that is, adolescents with high HL may be subjected to greater advertising influences.[36] Although health-related information is without a doubt a necessary condition to attain a healthy lifestyle, the results of this study, in addition to those of prior investigations,[36,37] strongly suggest that it is not sufficient for preventing (risky) substance use in adolescents.

Understanding and appraising health-related information had the largest effect of all HL components investigated in this study on adolescents' substance use behaviors. Specifically, individuals who found it easier to understand and appraise available information showed beneficial outcomes (i.e., a lower frequency and amount) in almost all indicators of smoking and drinking, except for the number of drinks per occasion and the lifetime drinking frequency. In contrast, applying health-related information had a small effect only on those two indicators. Moreover, the factor applying health-related information consisted of only two items, which were both related to adhering to a doctor's recommendation. In this context, it is disputable whether doctors give specific information/advice on substance use for otherwise healthy adolescents. Similarly, most health-related information for this age-group is either school based, provided by caregivers, or derived by the adolescents themselves from different media sources.

The differential effects of the three HL components on adolescents' substance use behaviors highlight the complexities involved in translating available information to the enactment of (positive) health behaviors.[32] Nutbeam[48] proposed a conceptual model of HL, which involves several core skill components of HL, namely, functional literacy (reading comprehension, numeracy, and, by extension, also information search skills),[32] interactive or communicative literacy (deriving meaning from, and applying, health knowledge to personal circumstances), and critical literacy (critically evaluating information and, by extension, also skills needed to take social and political actions to address the determinants of health), each building on the preceding one. Although health-related education provides access to information, which is a necessary precondition to acquiring higher level skills, there is a paucity of research on how these interventions may be conceptualized to support the development of higher level HL in adolescents.[32] However, as supported by the results of this investigation, these higher level HL components seem to be decisive in promoting positive health behaviors. Further research, including longitudinal studies, will be necessary to understand the complex, navigational processes and to evaluate the potential causal link between HL and substance use.[32] Future studies are also advised to consider the importance of the social and familial context in which HL occurs, including the influence of peers, which seems particularly relevant for adolescents,[30] to enable a more grounded, real-world conceptualization of adolescents' HL.[32]

Our results support those of numerous prior studies in that tobacco use and alcohol use have their genesis in adolescence.[3,4] Specifically, a large proportion of participants who reported to have used these substances has done so for the first time by the age of 14 years, and frequency and amount of use increased with age. Moreover, our findings confirm high rates of alcohol use and smoking amongst Austrian adolescents.[5,6] Besides an urgent need to adequately implement effective tobacco and alcohol control policies in Austria, these results highlight the necessity to expand efforts to develop and implement high-quality interventions, particularly those targeted at adolescents. Given the overall low HL status in Austria[29] in addition to the finding that adolescents who found it easier to understand and appraise and apply health-related information smoked and drank less, improving (higher level) HL may be an important starting point. However, although HL can contribute to our understanding of how to develop effective interventions to reduce and prevent smoking and drinking behaviors, interventions should not consider this in isolation. Instead, there is a need to use comprehensive approaches to design health interventions for future research that consider integrating HL with other effective approaches.

Adolescence is characterized by many physical, emotional, and cognitive changes.[49] This may be a pivotal stage for intervention and prevention of risky substance use, at a time when young people are developmentally poised to attain autonomy and to apply the necessary skills to engage in health-promoting activities.[30,32,50] While adolescents use multiple sources of health-related information, including school-based information, magazines, and TV, the most prominent source in this age-group is the Internet.[32,37] This indicates that Internet-based interventions, targeted specifically at adolescents, may be particularly useful tools for providing health-related information and supporting the development of HL. Given the flood of information provided online, practitioners may promote lists of websites considered to provide reliable and valid information, such as those provided by Health On the Net Foundation,[51] to prevent misinformation of adolescents. Moreover, readability of materials is critical to ensure that adolescents are able to understand the content and consequently can use this information to guide their choices.[30]

The present study is one of the very few studies investigating the link between HL and adolescents' substance use behaviors. Furthermore, it considers different components of HL. A limitation of our study that merits comment is that around one-third of participants responded with 'don't know' to at least one HL item. The HLS-EU short form used to measure HL in the current investigation was psychometrically tested and linguistically revised to ensure comprehensibility by adolescents.[41] However, adolescents may have less interaction with the healthcare system and less experiences with serious illnesses, as compared with adults.[30] Furthermore, our analyses indicate a lack of discriminant validity between 'finding' and 'understanding and appraising' and between 'understanding and appraising' and 'applying' health-related information. Therefore, the results regarding differential

effects of the three HL components on smoking and drinking behaviors have to be interpreted with caution.

Further efforts in developing and validating tools to adequately assess HL in adolescent populations are necessary. These should consider a broader concept of HL, which is also applicable in the absence of an illness or experience with the healthcare system. In addition, we need to better understand the sources and nature of adolescents' health-related information before drawing definite conclusions about the relevance of different HL components for adolescents' substance use behavior.

Author statement

Ethical approval

The Ethics Committee of the Austrian Federal Ministry of Education approved the study protocol for the 2013/2014 survey.

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Competing interests

None to declare.

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