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# Health Literacy throughout adolescence: Invariance and validity study of three measurement scales in the general population

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1 **Title:** Health Literacy throughout adolescence: invariance and validity study of three  
2 measurement scales in the general population.

3

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35

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42 Resources; Validation; Writing review & editing; **Sylvie Azogui-Levy**: Investigation;  
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46 administration; Resources; Validation; Writing original draft and review & editing.

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## 52 **Abstract**

53 **Objective.** To simultaneously investigate the psychometric properties of three recently  
54 developed health literacy measurement scales throughout adolescence in the general  
55 population.

56 **Methods.** French versions of the Health Literacy for School-Aged Children (HLSAC,  
57 unidimensional) scale, the Health Literacy Assessment Scale for Adolescents (HAS-A,  
58 multidimensional) and the 16-item European Health Literacy Survey questionnaire (HLS-EU-  
59 Q16, unidimensional) were completed by 1 444 adolescents in 8<sup>th</sup>, 9<sup>th</sup>, 11<sup>th</sup> grade in general  
60 school and 11-12<sup>th</sup> grade in vocational school. Psychometric properties were studied using  
61 confirmatory factor analysis, McDonald's omega coefficient and hypothesis testing.

62 **Results.** Structural validity was acceptable (HLS-EU-Q16) to good (HAS-A and HLSAC), no  
63 measurement invariance issue was found and internal consistency was acceptable for the  
64 three scales (0.68-0.84). Convergent validity was low (Pearson correlation coefficients<0.5)  
65 and the only scale for which results were in agreement with *a priori* hypotheses was the  
66 HLSAC.

67 **Conclusions.** Our results were supportive of the use of HLSAC to assess health literacy during  
68 adolescence but the HAS-A, with a slightly better structural validity, can also be promoted  
69 due to its three measured dimensions.

70 **Practice Implications.** The use of these scales in practice will help to focus on health literacy,  
71 a critical factor for prevention and health promotion in adolescence.

72

## 73 **1. Introduction**

74 Health literacy (HL) has been defined as "*the cognitive and social skills which determine the*  
75 *motivation and ability of individuals to gain access to, understand and use information in*  
76 *ways that promote and maintain good health*" [1]. Interest in this concept has been growing  
77 in the public health literature since the 2000s, owing to the works of Nutbeam, Osborne et  
78 al., or the European HL Survey group, among others, who have developed conceptual  
79 models for a more precise understanding of HL [2–4]. All these models encompass the three  
80 aspects of the modern conceptualization of HL: *functional HL*, which involves basic skills  
81 (reading, writing, etc.) and allows access to health information; *interactive HL*, which uses  
82 more advanced cognitive skills to understand this information; and finally *critical HL*, which  
83 involves in-depth cognitive and social skills leading ultimately to better control of life events  
84 [4].

85 Several studies have shown links between low HL and poor health status, limited survival,  
86 and higher health care costs [5–8]. The central role of HL in health inequities over the world  
87 was highlighted by the WHO, which regards HL as "a critical determinant of health" and a  
88 resource that "must be an integral part of the skills and competencies developed over a  
89 lifetime, first and foremost through the school curriculum" [1,9]. It is becoming increasingly  
90 clear that the HL can also be seen as a mediator of health inequalities [10–12]. However,  
91 most of the studies on HL have been conducted in adults and very little research, specifically  
92 involving the modern conceptualization of HL, have been conducted in adolescents [13–15].

93 Adolescence is often described as a period of opportunity for prevention and health  
94 promotion interventions because fundamental processes of cognitive, physical and  
95 emotional development are under construction during this period [10]. It is also at that time

96 that independent decision-making begins [12]. It is therefore crucial to arm adolescents with  
97 accurate and reliable health information that can help them adopt healthy behaviors early in  
98 life and to continue these behaviors later. Good access to, understanding, critical appraisal  
99 and use of such information are thus necessary to enable them to take charge of their own  
100 health [12,13]. This is all the more essential in view of the widespread access to information  
101 via the Internet, which has raised serious concerns about the correctness and validity of the  
102 information that adolescents obtain.

103 A recent systematic review identified 29 HL measurement instruments used in children and  
104 adolescents, 15 of which measured all three the HL domains (functional, interactive and  
105 critical) [14]. Two of these instruments were brief and designed to be self-administered by  
106 adolescents from 13 years of age in general settings: the unidimensional Health Literacy for  
107 School-Aged Children (HLSAC, S1 Table) with 10 items covering five core components of HL  
108 (theoretical knowledge, practical knowledge, critical thinking, self-awareness and  
109 citizenship), and the multidimensional Health Literacy Assessment Scale for Adolescents  
110 (HAS-A, S2 Table) with 15 items related to three dimensions (“Communication:  
111 communicating health information”, “Confusion: confusion about health information” and  
112 “Functional HL: understanding health information”) [15,16]. Although these measures have  
113 been developed in different samples, their measurement properties appear quite similar,  
114 despite some differences in terms of structural validity (more evidence for validity for HAS-A)  
115 and hypothesis testing (better agreement with a priori hypotheses for HLSAC). Another well-  
116 validated and widely used instrument to measure HL is the (unidimensional) 16-item  
117 European Health Literacy Survey (HLS-EU-Q16) [17–19]. This short version of the original 47-  
118 item Health Literacy Survey tool covers four health information processing skills (accessing,  
119 understanding, appraising, and applying health information) applied to three health contexts

120 (healthcare, disease prevention, and health promotion) (S3 Table) [20]. Although the HLS-  
121 EU-Q16 was developed for use among adults in the general population, it has also been used  
122 with adolescents [18,19]. However, its measurement properties have never been specifically  
123 assessed for use amongst adolescents, and some studies suggest that it may not be well  
124 adapted for that purpose [21].

125 In order to enhance the use of HL as a critical factor in prevention and health promotion  
126 aimed at adolescents in the general population, this study aimed to investigate the  
127 psychometric properties of the HLSAC, HAS-A and HLS-EU-Q16 for use with young people in  
128 the age range between 13 to 19 years-old in a sample from the general population. In  
129 particular, the purpose was to assess measurement invariance across sex, as it is a  
130 characteristic that is almost systematically studied in all studies, and throughout  
131 adolescence, to ensure that the scales measure the same construct in an identical way  
132 throughout this developmental period, so they can be used to evaluate changes in HL level in  
133 longitudinal studies. An additional aim was to assess whether these 3 scales measure  
134 different or related HL constructs by investigating convergent validity.

## 135 **2. Methods**

### 136 **2.1. Data collected**

#### 137 *2.1.1. French version of the three HL scales*

138 The HLSAC consists of 10 items of the form “I am confident that...”, to be scored on 4-point  
139 Likert response scales ranging from “not at all true” to “absolutely true”, leading to a total  
140 score ranging from 10 to 40 (high HL) (S1 Table). Thresholds may be applied to classify HL  
141 levels in three categories “low HL” ( $\leq 25$ ), “moderate HL” (26 to 35) and “high HL” ( $> 35$ ) [22].

142 In the development study, the Cronbach alpha was 0.93 and a one-factor confirmatory  
143 factor analysis (CFA) model had a good fit to the data [15].



144 The HAS-A consists of three subscales: communication, confusion and functional HL,  
145 composed of 5, 4 and 6 items respectively. Each item is to be scored on a 5-point Likert  
146 response scale leading to 3 subscale scores ranging from 0 to 20 (high communication  
147 related HL), 0 to 16 (low confusion related HL) and 0 to 24 (low functional HL) (S2 Table). In  
148 the development study, the Cronbach alpha was 0.77, 0.73 and 0.76 for the three subscales,  
149 respectively, which had been identified using an exploratory factor analysis [16].

150 The HLS-EU-Q16 consists of 16 items of the format "How difficult is it for you to ...", to be  
151 scored on 4-point Likert response scales ranging from "very easy" to "very difficult". A total  
152 score ranging from 0 to 16 (high HL) is computed by dichotomizing the replies, with the "very  
153 easy" and "easy" categories merged into a score of 1 and the "difficult" and "very difficult"  
154 merged into 0), and summing the scores thus obtained for the 16 items (S3 Table). Two  
155 thresholds are commonly used to define three levels of HL: inadequate ( $\leq 8$ ), problematic ( $> 8$   
156 and  $\leq 12$ ) and adequate ( $> 12$ )[19,23,24]. Psychometric properties were studied in adults  
157 using a Rasch analysis, and Cronbach alpha was 0.81[17,19,23].

158 Five French experts from various disciplines (epidemiology, psychometrics, general  
159 medicine, public health, health education) with very high levels of English language  
160 proficiency and an English-French translator independently translated the English versions of  
161 the HAS-A and HLSAC into French. A consensus meeting was then held to arrive to a  
162 consensual French version of the two scales. No back-translation was performed, as this has  
163 recently been proven unnecessary [25]. For the HLS-EU-Q16, the French version that had  
164 previously been validated for use among adults was used [17] (S1, S2 and S3 Tables).

165

166

167 *2.1.2. Other characteristics*

168 The French version of the three HL scales were compiled in a questionnaire along with  
169 questions on socio-demographic characteristics (age, sex, language spoken at home,  
170 parents' education), weight and height, and chronic diseases.

171 **2.2. Samples**

172 The protocol, approved by the National Institute of Health and Medical Research (Institut  
173 national de la santé et de la recherche médicale - Inserm) ethics review board (IRB00003888,  
174 2018/11/12) described three steps in which adolescents were involved. Before the beginning  
175 of each step, a letter with information about the study was provided to the adolescent (age-  
176 adapted) and to his/her parent(s) (if minor). The adolescent (and/or his/her parents) who  
177 did not want to participate to the study provided a signed non-participation form. At the  
178 beginning of each step, the study was presented to the adolescent, then each adolescent  
179 individually completed the questionnaire (i.e., 3 HL scales and other characteristics) and  
180 returned it in an urn in a sealed envelope to preserve anonymity.

181 **2.3. Focus groups**

182 The first step aimed to assess acceptability and comprehensiveness of each translated item  
183 of the three HL scales through two focus groups: 1) aged 11-13 years: 7 males, 5 females; 2)  
184 aged 14-17 years: 4 males, 6 females. After the completion of the questionnaire (from 15 to  
185 35 minutes), a comprehensive discussion was held in each group to identify understanding  
186 difficulties and suggestions of change. The consensual French versions of the 3 HL scales  
187 were not modified following the focus group however a significant number of  
188 comprehension issues was expressed by adolescents aged 11-13 years, particularly  
189 concerning the HLS-EU-Q16. The readability level of the translations, assessed using the  
190 Flesch Readability Score adapted to texts written in French, was 75.5 (7<sup>th</sup> grade) for the

191 HLSAC, 63.5 (8<sup>th</sup> – 9<sup>th</sup> grade) for the HAS-A, and 48 (undergraduate – bordering end of high-  
192 school) for HLS-EU-Q16 [26].

#### 193 **2.4. Pilot testing**

194 The second step aimed to evaluate the quality of questionnaire completion in 4 classes in 3  
195 schools in the Paris area (following the focus groups, we decided to remove the 7<sup>th</sup> grade  
196 pupils from the target population): 8<sup>th</sup> grade (N=27, mean age=13.5 years, 18 males), 9<sup>th</sup>  
197 grade (N=28, mean age=14.5 years, 13 males), 11<sup>th</sup> grade (N=30, mean age= 16.6 years, 8  
198 males) and 11<sup>th</sup> grade in a vocational school (N=23, mean age=17.7 years, all males). Once all  
199 the adolescents had returned the questionnaires, a comprehensive discussion with the  
200 whole class was held to assess acceptability of the questionnaire. Only a slight change was  
201 made on the item 1 of the HAS-A which began with “Est-il facile pour vous...” (“Is it easy for  
202 you...”) which was turned in “Est-ce que ça vous arrive de...” (“Do you happen to...”) after  
203 this pilot testing. Most of the other comments concerned the HLS-EU-Q16 which was  
204 considered as too complicated to fill in.

#### 205 **2.5. Study of the psychometric properties**

206 The last step aimed to assess the psychometric properties of the three HL scales in a large  
207 sample of adolescents in 8<sup>th</sup>, 9<sup>th</sup>, 11<sup>th</sup> grade in general school and 11-12<sup>th</sup> grade in vocational  
208 school. The minimal sample size was set at 1200 (300 in each grade [27]) and increased by  
209 25% due to possible truancy, nonsensical answers to the questionnaire and general setback  
210 that could prevent an entire class from completing the questionnaire. To ensure  
211 representation (but not statistical representativeness) of the various social backgrounds that  
212 exist in France, four geographical areas were chosen in which middle and high-schools were  
213 randomly selected, in which classes of each needed grade were randomly selected: Aveyron  
214 (rural), Hautes Pyrénées (semi-rural), Haute Garonne (semi-urban), Paris (urban).

## 215 **2.6. Statistical analyses**

216 Categorical data were summarized as frequencies (%) and quantitative data as means  $\pm$   
217 standard deviation. Floor or ceiling effects at the scale level were considered to be present if  
218 more than 15% of respondents achieved the lowest or highest possible score, respectively  
219 [28]. At the item level, these effects were considered to be present if more than 75%  
220 answered the lowest or highest response category [29].

221 The structural validity of each HL scale was studied using confirmatory factor analysis (CFA)  
222 with a robust estimator for categorical data, the Weighted Least Square Means and  
223 Variances adjusted [30]. For each scale, the model fitted was the one described by the  
224 authors of the initial development study: one dimension for HLSAC and HLS-EU-Q16, three  
225 dimensions for HAS-A [15,16,23]. Model fit was assessed using the Comparative Fit Index  
226 (CFI, good fit if  $>0.95$ , poor fit if  $<0.90$ , acceptable fit otherwise) and the Root Mean Square  
227 Error Approximation (RMSEA, good fit if  $<0.06$ , poor fit if  $>0.1$ , acceptable fit otherwise) [31].  
228 Measurement invariance was tested consecutively across groups defined by the grade and  
229 sex. A multigroup CFA and the classic three-step sequence were used to investigate  
230 configural, metric and scalar invariance, i.e. three different nested models having increasing  
231 constraints were fitted to test these three levels of invariance [32,33]. For grade invariance  
232 for example, the same model was hypothesized in the four grade groups and the sequence  
233 of nested model tests was: 1) configural invariance: unconstrained factor loadings and item  
234 thresholds; 2) metric invariance: factor loadings constrained to be equal across the four  
235 grades and unconstrained item thresholds; 3) scalar invariance: factor loadings and item  
236 thresholds constrained to be equal across the four grades. Each level of measurement  
237 invariance was considered to be present if the fit indices difference,  $\Delta$ CFI and  $\Delta$ RMSEA,  
238 between nested models was  $\geq -0.01$  and  $\leq 0.015$  respectively [34,35].

239 Internal consistency was assessed using McDonald's omega coefficient (acceptable if  $\geq 0.7$ )  
240 [36]. To assess convergent validity, the correlation between HL scores (and subscale scores)  
241 was assessed using Pearson coefficients (acceptable if  $> 0.6$ ) and a weighted kappa  
242 coefficient (quadratic weights) was computed to assess concordance (acceptable if  
243  $\text{kappa} > 0.6$ ) between the classifications of HL level obtained using HLSAC and HLS-EU-Q16  
244 [29,37]. Finally, for hypothesis testing, Cohen's d (corrected for uneven group size if needed)  
245 was computed to assess effect size (considered as small if  $d = 0.2$ , medium if  $d = 0.5$  and large if  
246  $d = 0.8$ ) and mean score of each HL scale was compared, using one-way analyses of variance  
247 or Student t-tests between adolescents according to sex (*a priori* hypothesis: no difference),  
248 grade repetition (lower HL if grade repetition), parents educational level (higher HL for  
249 higher education levels), main language at home (higher HL for French), chronic disease  
250 (higher HL if chronic disease), weight classification (higher HL if normal weight) [19,38–44].  
251 Statistical tests were two-sided and a  $p\text{-value} < 0.05$  was considered significant. Analyses  
252 were performed using Stata v.14 software for data management and basic statistics and  
253 Mplus v7.4 software for the CFA, which implements full information maximum likelihood to  
254 handle missing data [30,45].

### 255 **3. Results**

256 The survey took place in 68 classes in 23 schools from Monday 9<sup>th</sup> to Friday 13<sup>th</sup> March 2020.  
257 As the national lockdown due to COVID-19 crisis took place in France the 16<sup>th</sup> of March, two  
258 vocational schools scheduled from Monday 24<sup>th</sup> to Friday 28<sup>th</sup> March because adolescents  
259 were in internship during the beginning of March could not be included in this study. Among  
260 the 1 490 adolescents who filled in the questionnaire, 9 gave nonsensical answers and 37  
261 responded to less than half of the items of the three HL scales. The characteristics of the

262 1 444 adolescents included in this study are summarized in the Table 1 according to the  
263 grade. The sex-ratio was balanced except in vocational schools in which boys were in  
264 majority. A language other than French was spoken at home for a third of the sample and  
265 one parent had at least a post-secondary education degree for half of the adolescents.  
266 Overall, adolescents were less in overweight or obesity in our sample than in general  
267 population (14.7% compared to 18.2% in [46]) and the proportion of adolescents who  
268 reported a chronic disease was high (20.8%) but similar with what was found in 2014 in  
269 France [47].

270 **Table 1. Characteristics of the sample according to the grade, N(%) unless otherwise stated**

	8 <sup>th</sup> grade	9 <sup>th</sup> grade	11 <sup>th</sup> and 12 <sup>th</sup> grades – vocational school	11 <sup>th</sup> grade – general school	Total
<b>N</b>	357	387	285	415	1444
<b>Age (years), median (Q1-Q3)</b>	13 (13-14)	14 (14-15)	17 (16-17)	16 (16-17)	15 (14-16)
<b>Girls</b>	177 (49.6)	203 (52.4)	113 (39.7)	226 (54.5)	719 (49.7)
<b>No grade repetition</b>	331 (93.0)	363 (93.8)	190 (66.7)	368 (88.7)	1252 (86.8)
<b>Live outside the family home</b>	2 (0.6)	5 (1.4)	54 (19.6)	31 (7.6)	92 (6.5)
<b>Main language at home</b>					
· French	215 (60.2)	235 (60.7)	198 (69.5)	299 (72.1)	947 (65.6)
· French and other	128 (35.9)	139 (35.9)	73 (25.6)	107 (25.8)	447 (31.0)
· Other	14 (3.9)	13 (3.4)	14 (4.9)	9 (2.2)	50 (3.5)
<b>Parents education</b>					
· Both parents with high school or lower	58 (16.3)	71 (18.4)	92 (32.3)	70 (16.9)	291 (20.2)
· At least one with post-secondary school	154 (43.1)	202 (52.2)	85 (29.8)	279 (67.2)	720 (49.4)
· Unknown	145 (40.6)	114 (29.5)	108 (37.9)	66 (15.9)	433 (30.0)
<b>Chronic disease</b>	68 (19.4)	69 (18.4)	56 (20.1)	100 (24.6)	293 (20.8)
<b>Weight classification*</b>					
· Under weight	40 (12.8)	42 (11.7)	43 (16.6)	40 (10.0)	165 (12.4)
· Normal weight	234 (74.8)	265 (73.6)	171 (66.0)	311 (77.6)	981 (73.6)
· Overweight	30 (9.6)	45 (12.5)	36 (13.9)	41 (10.2)	152 (11.4)
· Obesity	9 (2.9)	8 (2.2)	9 (3.5)	9 (2.2)	35 (2.6)

271 \* Adapted to sex and age, according to the International Obesity Task Force. Q1: first quartile, Q3: third quartile

272

273 The distribution of the answers to each item (of each) of the 3 HL scales is described in S4  
274 Table. There was no ceiling or floor effect at the item level and the proportion of missing  
275 answers was always <6%. At the scale level, a ceiling effect was observed for the HLS-EU-Q16  
276 scale with 269 (21.0%) adolescents with the highest score as described in Fig 1. Concerning  
277 structural validity, as shown in Table 2, a good fit was found for the three-dimension HAS-A  
278 model while only acceptable to good fit was found for unidimensional HLSAC model and  
279 acceptable fit for unidimensional HLS-EU-Q16 model. No measurement invariance issue  
280 across grades was found for the three HL scales, neither across sex (Table 2). The internal  
281 consistency was acceptable for every scale (nearly acceptable for the HAS-A confusion scale)  
282 with a McDonald's omega coefficient was 0.82 for HLSAC, 0.84 for HLS-EU-Q16 and 0.73,  
283 0.68 and 0.77 for the communication, confusion and functional HAS-A subscales  
284 respectively.

285 **Fig 1. Distribution of the score for the Health Literacy for School-Aged Children (HLSAC), the**  
286 **Health Literacy Assessment Scale for Adolescents (HAS-A) and 16-item European Health**  
287 **Literacy Survey (HLS-EU-Q16) scales in the whole sample.**



288 **Table 2. Fit indices of the factor models and study of measurement invariance across grade and sex for the Health Literacy for School-Aged**  
 289 **Children (HLSAC), the Health Literacy Assessment Scale for Adolescents (HAS-A) and 16-item European Health Literacy Survey (HLS-EU-Q16).**

Characteristic	Invariance model (constraints)	Chi-square (DF)	CFI	RMSEA (90%CI)	ΔCFI	ΔRMSEA
Grade	<b>HLSAC</b>					
	· Configural (no constraints)	504.0 (140)	0.950	0.086 (0.078-0.094)	-	-
	· Metric (loadings)	478.1 (167)	0.957	0.072 (0.065-0.080)	0.007	-0.014
	· Scalar (loadings, thresholds)	578.2 (224)	0.951	0.067 (0.060-0.073)	-0.006	-0.005
	<b>HAS-A</b>					
	· Configural (no constraints)	718.7 (348)	0.961	0.054 (0.049-0.060)	-	-
	· Metric (loadings)	723.9 (384)	0.964	0.050 (0.044-0.055)	0.003	-0.003
	· Scalar (loadings, thresholds)	938.4 (510)	0.954	0.048 (0.043-0.053)	-0.010	-0.002
	<b>HLS-EU-Q16</b>					
	· Configural (no constraints)	1221.4 (416)	0.920	0.074 (0.069-0.078)	-	-
	· Metric (loadings)	1345.9 (461)	0.912	0.073 (0.069-0.078)	-0.008	-0.001
	· Scalar (loadings, intercepts)	1315.4 (527)	0.921	0.065 (0.060-0.069)	0.009	-0.008
Sex	<b>HLSAC</b>					
	· Configural (no constraints)	359.7 (70)	0.959	0.076 (0.069-0.084)	-	-
	· Metric (loadings)	324.1 (79)	0.966	0.066 (0.059-0.074)	0.007	-0.010
	· Scalar (loadings, thresholds)	405.1 (98)	0.957	0.066 (0.060-0.073)	-0.009	0.000
	<b>HAS-A</b>					
	· Configural (no constraints)	533.5 (174)	0.962	0.054 (0.048-0.059)	-	-
	· Metric (loadings)	523.1 (186)	0.964	0.050 (0.045-0.055)	0.002	-0.004
	· Scalar (loadings, thresholds)	657.8 (228)	0.954	0.051 (0.047-0.056)	-0.010	0.001
	<b>HLS-EU-Q16</b>					
	· Configural (no constraints)	1012.6 (208)	0.920	0.073 (0.069-0.078)	-	-
	· Metric (loadings)	1018.1 (223)	0.921	0.071 (0.066-0.075)	0.001	-0.002
	· Scalar (loadings, intercepts)	959.5 (246)	0.929	0.064 (0.059-0.068)	0.008	-0.007

290 DF: Degree of Freedom, CFI: Comparative Fit Indices, RMSEA: Root Mean Square Error Approximation, CI: Confidence interval

291 Convergent validity was low. Pearson correlation coefficients between HL scales were all  
 292 <0.6 (0.40, -0.21, -0.34 and 0.47 between HLSAC and HAS-A communication, confusion,  
 293 functional subscales and HLS-EU-Q16 respectively; 0.38, -0.29 and -0.36 between HLS-EU-  
 294 Q16 and HAS-A communication, confusion and functional respectively). The weighted kappa  
 295 coefficient assessing the concordance between HL levels defined using HLSAC and HLS-EU-  
 296 Q16 thresholds was equal to 0.24 with 620 (50.5%) adolescents classified as having an  
 297 adequate HL according to HLS-EU-Q16 while classified as having low or moderate HL  
 298 according to HLSAC (Table 3). Concerning hypotheses testing, as described in Table 4, the  
 299 only scale for which results were in agreement with *a priori* hypotheses was the HLSAC with  
 300 small to medium effect sizes according to Cohen's d (except for grade repetition for which  
 301 only a tendency was observed). Results concerning the two other scales were rarely in  
 302 agreement with *a priori* hypotheses.

303 **Table 3. Concordance between health literacy levels according to the Health Literacy (HL)**  
 304 **for School-Aged Children (HLSAC) and the 16-item European Health Literacy Survey**  
 305 **(HLSEU-16) scales. N (%), kappa coefficient=0.1.**

HLSEU-16 (score)	HLSAC (score)		
	Low HL (<26)	Moderate HL (26 to 35)	High HL (>35)
Inadequate HL (<9)	35 (24.1)	38 (4.2)	2 (1.1)
Problematic HL (9 to 12)	64 (44.1)	284 (31.7)	10 (5.5)
Adequate HL (>12)	46 (31.7)	574 (64.1)	170 (93.4)
<b>Total</b>	145 (100.0)	896 (100)	182 (100)

306

307 **Table 4. Hypotheses testing for the School-Aged Children (HLSAC), the Health Literacy Assessment Scale for Adolescents (HAS-A) and the 16-**  
 308 **item European Health Literacy Survey (HLS-EU-Q16). *A priori* hypotheses concerning Health Literacy (HL) were: no difference between sex,**  
 309 **higher HL in higher grades, higher HL in higher parents' education levels, higher HL for French as main language at home, higher HL if chronic**  
 310 **disease, higher HL if normal weight. mean±SD**

	HLSAC	HAS-A			HLS-EU-Q16
		Communication	Confusion*	Functional*	
<b>Sex: Cohen d (p-value)</b>	0.07 (0.180)	0.01 (0.887)	0.19 (<0.001)	0.22 (<0.001)	0.12 (0.028)
· Girls	30.4±4.5	13.4±3.4	4.9±3.1	7.4±4.3	12.9±2.7
· Boys	30.7±4.6	13.4±3.4	4.3±3.3	6.4±4.6	13.3±2.5
<b>Grade repetition: Cohen d (p-value)</b>	0.15 (0.076)	0.12 (0.135)	0.01 (0.873)	0.14 (0.080)	0.07 (0.394)
· No	30.6±4.5	13.5±3.4	4.6±3.2	6.8±4.4	13.1±2.5
· Yes	30.0±4.9	13.1±3.9	4.6±3.3	7.5±5.2	13.0±2.8
<b>Parents education: Cohen d (p-value)</b>	0.33 (<0.001)	0.23 (<0.001)	0.14 (0.052)	0.22 (0.002)	0.15 (0.034)
· Both parents ≤high school	30.1±4.7	13.1±3.3	5.0±3.4	7.5±4.9	12.9±2.7
· At least one ≥post-secondary	31.2±4.1	13.9±3.2	4.6±3.2	6.5±4.2	13.3±2.4
<b>Main language at home: largest Cohen d (p-value)</b>	0.56 <sup>a</sup> (<0.001)	0.09 <sup>b</sup> (0.316)	0.07 <sup>a</sup> (0.868)	0.42 <sup>a</sup> (0.018)	0.35 <sup>a</sup> (0.050)
· French	30.8±4.5	13.5±3.3	4.6±3.1	6.8±4.4	13.2±2.5
· French and other	30.2±4.5	13.2±3.7	4.7±3.3	6.9±4.6	13.0±2.6
· Other	28.1±5.2	13.3±3.4	4.8±3.6	8.7±4.6	12.3±3.1
<b>Chronic disease: Cohen d (p-value)</b>	0.19 (0.006)	0.07 (0.284)	0.11 (0.116)	0.00 (0.961)	0.00 (0.983)
· No	30.4±4.5	13.4±3.4	4.6±3.2	6.9±4.5	13.1±2.6
· Yes	31.2±4.6	13.6±3.5	4.9±3.2	6.9±4.4	13.1±2.5
<b>Weight classification** : largest Cohen d (p-value)</b>	0.30 <sup>c</sup> (0.005)	0.11 <sup>d</sup> (0.513)	0.16 <sup>b</sup> (0.668)	0.15 <sup>b</sup> (0.131)	0.18 <sup>b</sup> (0.777)
· Under weight	30.7±4.7	13.7±3.4	4.6±3.1	7.3±4.4	13.1±2.5
· Normal weight	30.8±4.4	13.5±3.4	4.6±3.2	6.7±4.5	13.1±2.5

· Overweight	29.6±4.8	13.1±3.7	4.8±3.5	7.5±5.1	13.1±2.7
· Obesity	29.3±3.9	13.1±2.9	5.1±3.0	7.6±4.3	12.7±2.8

311 Statistical tests are Student or anova as appropriate. Cohen'd is corrected for uneven group size if necessary. \* Higher scores mean lower HL.

312 \*\*Adapted to sex and age, according to the International Obesity Task Force. Largest Cohen's d between: <sup>a</sup>"French" and "Other", <sup>b</sup>"French"

313 and "French and other", <sup>c</sup>"Normal weight" and "Obesity", <sup>d</sup>"Under weight" and "Obesity"

## 314 **4. Discussion and conclusion**

### 315 **4.1. Discussion**

316 This study is, to our knowledge, the first one to assess simultaneously the psychometric  
317 properties of three recently developed HL scales on the same large sample of adolescents  
318 from various social backgrounds. This design of the study allowed to draw the following key  
319 results: First, these three scales showed measurement invariance across adolescence from  
320 13 years-old and measurement invariance across sex; Second, convergent validity is low,  
321 which means that the HL-related constructs measured by these three scales are different;  
322 Third, among the three HL scales, the HLS-EU-Q16 is the one of which the psychometric  
323 properties indicate that it is less appropriate for use amongst adolescents (acceptable fit of  
324 the CFA model compared to good fit for HAS-A, results rarely in agreement with *a priori*  
325 hypotheses compared to always in agreement for HLSAC, undergraduate readability level  
326 according to the Flesch Readability Score compared to 7<sup>th</sup> grade for the HLSAC) .

327 Measurement invariance is defined by Milsap as “a measuring device should function in the  
328 same way across varied conditions, so long as those varied conditions are irrelevant to the  
329 attribute being measured” [48]. It is recognized by the COSMIN initiative (COnsensus-based  
330 Standards for the selection of health Measurement Instruments) as an important  
331 psychometric property as it is closely related to construct validity [49]. Indeed, if a scale lacks  
332 of measurement invariance concerning a characteristic, it means that its factor structure is  
333 different according to this characteristic and thus, that the scale measures a different  
334 construct depending on this characteristic. Due to the developmental processes and changes  
335 of cognitive abilities that take place during the adolescence, measurement invariance is  
336 clearly important to check throughout the concerned age range whatever the construct

337 being measured. Our study is the first to show that the HLSAC, the HAS-A and the HLS-EU-  
338 Q16 scales are invariant throughout adolescence (and also concerning sex) which means that  
339 they can be used longitudinally to assess change in HL level during adolescence.

340 However, when assessing convergent validity, it was shown that the scores on these three  
341 measures are weakly correlated. This lack of convergent validity is further confirmed by the  
342 absence of concordance (weighted kappa=0.24) between the two HL level classifications  
343 resulting from the use of the thresholds for HLSAC and HLS-EU-Q16. This means that while  
344 these instruments are all supposed to measure HL, they do not measure the same construct.

345 It can be explained by the fact that the authors of each scale were guided by different HL  
346 definitions or conceptualizations, even if these three scales are supposed to encompass the  
347 three aspects (functional, interactive and critical) of HL. To develop the HAS-A, Manganello  
348 *et al.* explained that they used the Berkman's definition of HL ("the degree to which  
349 individuals can obtain, process, understand, and communicate about health-related  
350 information needed to make informed health decisions") [16,50]. The HL definition used by  
351 Sorensen *et al.* to develop the HLS-EU-Q16 is close to the Berkman's definition but  
352 "integrates the 'medical' conceptualization of HL with the broader 'public health'  
353 perspective of HL" with three domains of application: healthcare, disease prevention, health  
354 promotion [51]. Concerning the HLSAC, Paakkari *et al.* indicated that they were interested in  
355 HL conceptualized as a learning outcome and developed their tool with "the intention to  
356 move beyond HL assessment towards *how* HL can be developed further among the target  
357 group"[15]. It is important to be aware of these differences in order to decide which one of  
358 these three scales is most suitable for one's purpose.

359 Finally, while it was hypothesized before the beginning of the data collection which  
360 characteristics of the adolescents would be associated with HL, the only measure for which  
361 these associations were found was the HLSAC (except for grade repetition maybe due to a  
362 lack of power). The effect sizes were small to medium which may indicate a lack of  
363 discriminating power for this scale. For the two other scales, the absence of the expected  
364 associations may be due to the fact that the measured construct is not the one we expected  
365 to measure, or to the presence of a ceiling effect, which could be the case for the HLS-EU-  
366 Q16. This effect may decrease the precision of the score, and thus the power to detect  
367 expected associations, as it means that the measure is not sufficiently discriminating for a  
368 large part of the sample.

369 This study has some limitations. First, the adolescents were asked to complete 3 HL tools,  
370 with a total of 41 items that closely resemble each other. This may have reduced their  
371 motivation and introduced a form of bias. However, there were very few missing answers to  
372 the items of the three instruments, with only 9 participants giving nonsensical answers and  
373 only 37 responding to less than half of the items, i.e. 3.1% of the whole sample. Second, we  
374 did not assess the sensitivity to change and the test-retest reliability of the measures, which  
375 are two important psychometric properties to assess. Further studies should evaluate these  
376 properties as they have never been assessed for the HLSAC and the HAS-A [14].

## 377 **4.2. Conclusion**

378 To conclude, the three scales exhibited acceptable to good structural validity and  
379 measurement invariance throughout adolescence and across sex. However, the Flesch  
380 readability score (7<sup>th</sup> grade), the internal consistency (Mac Donald omega =0.82) and the  
381 hypotheses testing are more in favour of the use of the HLSAC to assess HL during



382 adolescence. On the other hand, the structural validity was slightly better for the HAS-A,  
383 which can be interesting as it may bring more analytic information due to the three  
384 measured dimensions. While it was not developed specifically for adolescents, the HLS-EU-  
385 Q16 could be chosen by some researchers as it could be useful to assess the change of HL  
386 level longitudinally throughout adolescence and adulthood. However, it should be  
387 considered that some adolescents may have problems understanding all the questions, as  
388 was noted during the focus groups and the pilot testing, and the readability Flesch score  
389 indicated that it is more suitable for undergraduate students. Moreover, for adolescents  
390 there also seems to be an important ceiling effect for this tool, which has also been observed  
391 in the adult population [17].

### 392 **4.3. Practice implications**

393 While adolescence is a period of opportunity for prevention and health promotion  
394 interventions, very few studies on HL have been conducted in adolescents, partly because of  
395 the lack of clear understanding on what is measured by the different existing HL  
396 measurement tools over the age span of 13-18 years. This study results clarify that the HL-  
397 related constructs measured by the HLSAC, the HAS-A and HLS-EU-Q16 scales are different  
398 (low convergent validity) while they all exhibited acceptable to good structural validity and  
399 measurement invariance throughout adolescence and across sex. Among the three HL  
400 scales, the HLS-EU-Q16 is the one of which the psychometric properties indicate that it is less  
401 appropriate for use amongst adolescents. As they are well suited and valid for adolescents  
402 from 13 to 19 years-old, the use of the HLSAC and HAS-A in clinical practice and research  
403 studies will help to focus on health literacy which is a critical factor for prevention and health  
404 promotion interventions in adolescence.

405

406

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## 577 **Supporting information**

578 **S1 Table: English and French versions of the Questionnaire with 10 items Health literacy**  
579 **for School-Aged Children (HLSAC)**

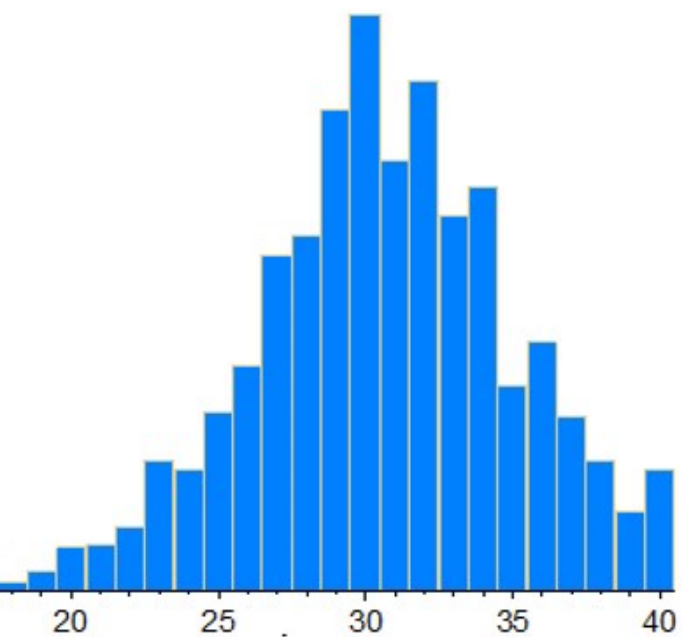
580 **S2 Table: English and French versions of the 15-item questionnaire Health literacy**  
581 **Assessment Scale for Adolescents (HAS-A)**

582 **S3 Table: English and French versions of the European Health Literacy Survey**  
583 **Questionnaire with 16 items (HLS-EU-Q16)**

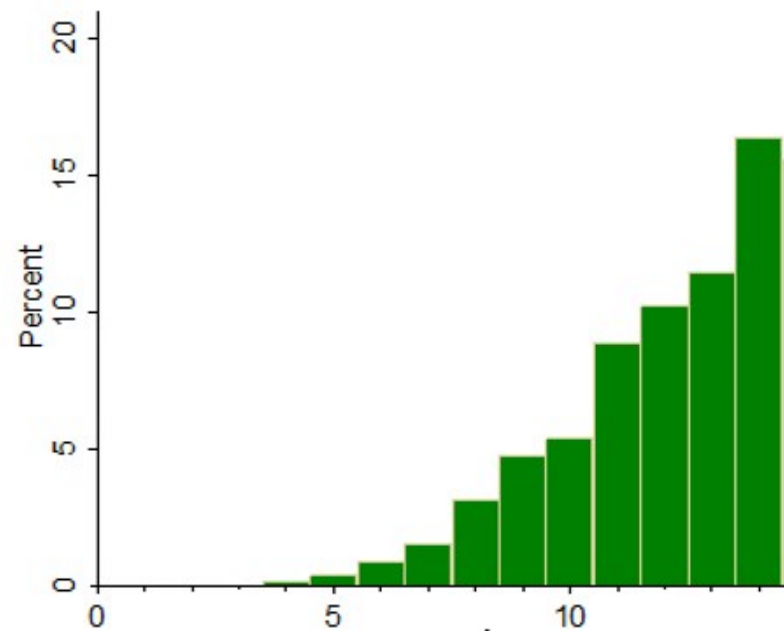
584 **S4 Table: Responses distribution to the 10 items of the Health Literacy for School-Aged**  
585 **Children (HLSAC) according to the grade – N (%)**

586

**HLSAC score**

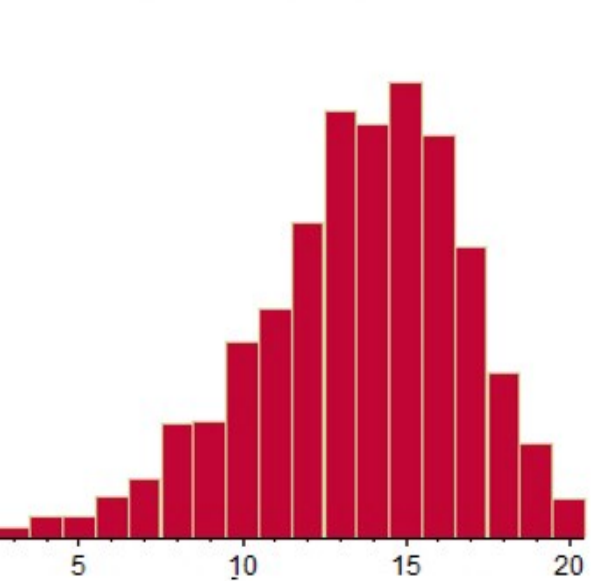


**HLSEU-16 score**

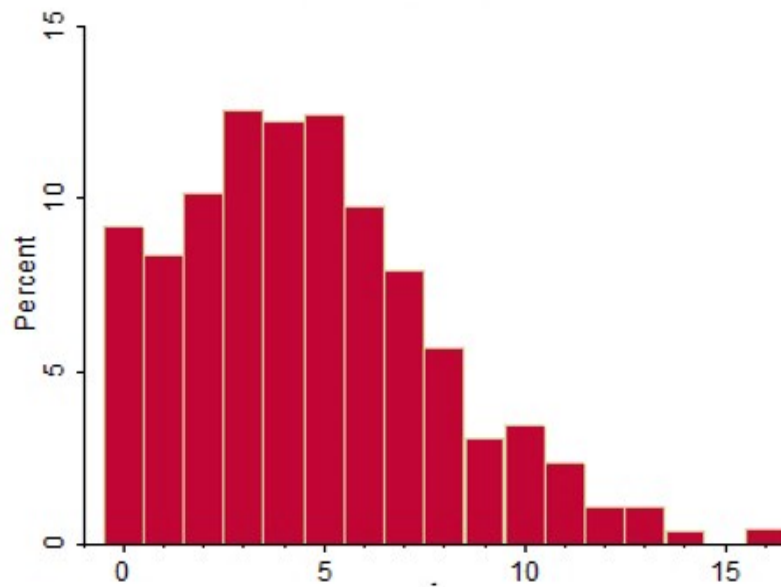


**HAS-A**

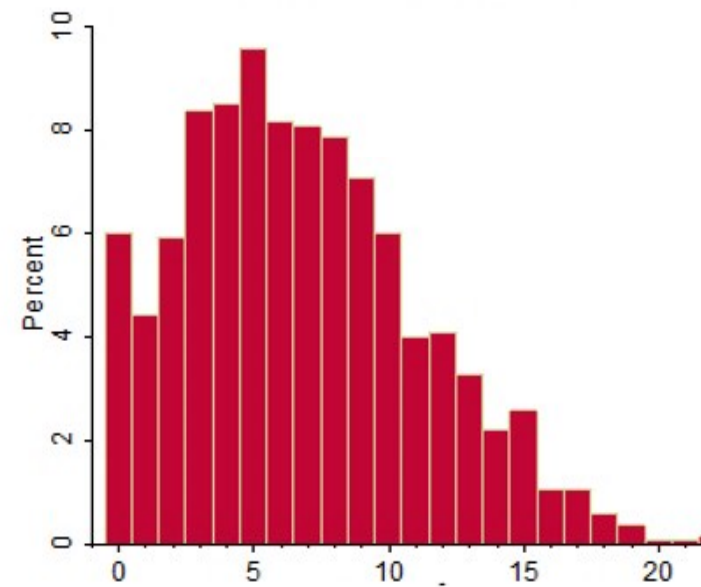
**Communication score**



**Confusion score**



**Functional score**



**S1 Table.** English and French versions of the Health literacy for School-Aged Children (HLSAC) Questionnaire (10 items, unidimensional)

For each item, possible answers are:

- En: **Not at all true / Not completely true / Somewhat true / Absolutely true**
- Fr : Pas du tout / Plutôt non / Plutôt oui / Tout à fait

---

En : **From the following options, choose the one that best describes your opinion**

Fr : Pour chaque proposition, choisissez la réponse qui correspond le mieux à ce que vous pensez

---

En: **I am confident that I have good information about health**

**1**

Fr : Je pense que je suis bien informé sur la santé

---

En: **I am confident that When necessary I am able to give ideas on how to improve health in my immediate surroundings (e.g. a nearby place or**

**2 area, family, friends)**

Fr : Je pense que si besoin, je suis capable de donner des idées pour améliorer la santé autour de moi (par ex : amis, famille, voisins, quartier)

---

En: **I am confident that I can compare health-related information from different sources**

**3**

Fr : Je pense que je sais comparer des informations sur la santé qui viennent de différentes sources (par ex : internet, presse, amis)

---

En: **I am confident that I can follow the instructions given to me by healthcare personnel (e.g. nurse, doctor)**

**4**

Fr : Je pense je suis capable de suivre les consignes que me donne le personnel soignant (par ex infirmière, médecin)

---

En: **I am confident that I can easily give examples of things that promote health**

**5**

Fr : Je pense que je peux facilement donner des exemples des choses qui sont bonnes ou mauvaises pour la santé

---

En: **I am confident that I can judge how my own actions affect the surrounding natural environment**

**6**

Fr : Je pense que je suis capable d'évaluer en quoi mes actions ont un effet sur la nature autour de moi

---

**S1 Table.** Continued

---

**7** En: I am confident that When necessary I find health-related information that is easy for me to understand

*Fr* : Je pense que si besoin, je trouve des informations sur la santé que je comprends facilement

---

**8** En: I am confident that I can judge how my behavior affects my health

*Fr* : Je pense que je suis capable d'évaluer en quoi mon comportement à un effet sur ma santé

---

**9** En: I am confident that I can usually figure out if some health-related information is right or wrong

*Fr* : Je pense que en général, j'arrive à déterminer si une information sur la santé est vraie ou fausse

---

**10** En: I am confident that I can give reasons for choices I make regarding my health

*Fr* : Je pense que je peux donner les raisons des choix que je fais concernant ma santé

---

**S2 Table.** English and French versions of the Health literacy Assessment Scale for Adolescents (HAS-A) questionnaire (15 items, 3 dimensions)

For each item, possible answers are:

- En: **Never / Rarely / Sometimes / Usually / Always**
- Fr : Jamais / Rarement / Parfois / Souvent / Toujours

---

**COMMUNICATION**

---

**1** En: **How often is it easy for you to ask your doctor questions about your health?**

Fr : Est-ce que ça vous arrive de poser des questions sur votre santé à votre médecin ?

---

**2** En: **How often does your doctor understand what you mean when you ask him or her a question about your health?**

Fr : Est-ce que votre médecin comprend ce que vous voulez dire quand vous lui poser une question ?

---

**3** En: **How often can you easily describe a health problem you have to your doctor?**

Fr : Est-ce que vous arrivez facilement à décrire votre problème de santé à votre médecin ?

---

**4** En: **How often does your doctor seem to understand you when you answer a question he or she asks?**

Fr : Est-ce que vous avez l'impression que votre médecin comprend quand vous répondez à ses questions ?

---

**5** En: **How often do you understand the answers your doctor gives to your questions?**

Fr : Est-ce que vous comprenez les réponses de votre médecin à vos questions ?

---

**CONFUSION**

---

**6** En: **How often do you get confused because you find different information about the same health topic?**

Fr : Est-ce que ça vous arrive d'être perdu parce que vous avez trouvé des informations différentes sur le même sujet de santé ?

---

**7** En: **How often do you get confused when your doctor tells you about taking a medicine?**

Fr : Est-ce que ça vous arrive d'être perdu quand votre médecin vous parle d'un médicament à prendre ?

---

**S2 Table.** Continued

<b>8</b>	<b>En: How often do you get confused when your doctor tells you about possible side effects from a medicine or treatment?</b> <i>Fr : Est-ce que ça vous arrive d'être perdu lorsque votre médecin parle d'effets négatifs possibles d'un traitement ?</i>
<b>9</b>	<b>En: How often do you get confused when your doctor tells you about test results, like results of an X-ray?</b> <i>Fr : Est-ce que ça vous arrive d'être perdu lorsque votre médecin vous donne les résultats d'examens, par exemple une radio ?</i>
<b>FUNCTIONAL HEALTH LITERACY</b>	
<b>10</b>	<b>En: How often do you get confused when reading instructions for medicine?</b> <i>Fr : Est-ce que ça vous arrive d'être perdu lorsque vous lisez les consignes pour prendre un médicament ?</i>
<b>11</b>	<b>En: How often do you have problems learning about an illness or health topic because of difficulty understanding the written information you get?</b> <i>Fr : Est-ce que vous avez des problèmes pour vous renseigner sur une maladie ou un sujet de santé parce que l'information écrite que vous trouvez est difficile à comprendre</i>
<b>12</b>	<b>En: How often do you think the forms you complete at your doctor's office are confusing?</b> <i>Fr : Est-ce que les papiers que vous remplissez chez votre médecin vous semblent difficiles à comprendre ?</i>
<b>13</b>	<b>En: How often are you confused by health information that has a lot of numbers and statistics?</b> <i>Fr : Est-ce que ça vous arrive d'être perdu quand il y a beaucoup de chiffres et de pourcentages dans les informations sur la santé ?</i>
<b>14</b>	<b>En: When you talk to people other than your doctor about health issues, how often are you confused by what they tell you?</b> <i>Fr : Quand vous parlez de santé avec d'autres personnes que votre médecin, est-ce que ça vous arrive d'être désorienté parce qu'elles vous disent ?</i>
<b>15</b>	<b>En: When reading brochures or hand-outs about health issues, how often do you need someone to help you read them?</b> <i>Fr : Est-ce que ça vous arrive d'avoir besoin qu'on vous aide à lire des dépliants ou d'autres documents sur la santé ?</i>

**S3 Table.** English and French versions of the European Health Literacy Survey Questionnaire (HLS-EU-Q16, 16 items, unidimensional)

For each item, possible answers are:

- En: **Very easy / Easy / Difficult / Very difficult**
- Fr: Très facile / Facile / Difficile / Très difficile

---

**En:** On a scale from very easy to very difficult, how easy would you say it is to...

**Fr:** *Indiquez, sur une échelle de très facile à très difficile, dans quelle mesure il est facile pour vous de...*

---

**En:** ...find information on treatments of illnesses that concern you?

**1**

**Fr:** *...trouver des informations sur les traitements des maladies qui vous concernent ?*

---

**En:** ...find out where to get professional help when you are ill? (Ex. such as doctor, nurse, pharmacist, psychologist)

**2**

**Fr:** *...savoir où obtenir l'aide d'un professionnel quand vous êtes malade ? (Par ex. médecin, infirmier, pharmacien ou psychologue)*

---

**En:** ...understand what your doctor says to you?

**3**

**Fr:** *...comprendre ce qu'un médecin vous dit ?*

---

**En:** ...understand your doctor's or pharmacist's instruction on how to take a prescribed medicine?

**4**

**Fr:** *...comprendre les consignes de votre médecin ou pharmacien sur la manière de prendre vos médicaments ?*

---

**En:** ...judge if you may need to get a second opinion from another doctor?

**5**

**Fr:** *...savoir quand il serait utile d'avoir l'avis d'un autre médecin ?*

---

**En:** ...use information your doctor gives you to make decisions about your illness?

**6**

**Fr:** *...utiliser les informations que le médecin vous donne pour prendre des décisions concernant votre maladie ?*

---

**En:** ...follow instructions from your doctor or pharmacist?

**7**

**Fr:** *...suivre les consignes de votre médecin ou pharmacien ?*

---

**En:** ...find information on how to handle mental health problems? (Ex. stress, depression or anxiety)

**8**

**Fr:** *...trouver des informations sur comment faire en cas de problèmes psychologiques ? (Par ex. stress, dépression ou anxiété)*

---

**S3 Table.** Continued

---

	<b>En:</b> ...understand health warnings about behavior such as smoking, low physical activity and drinking too much?
<b>9</b>	<b>Fr :</b> ...comprendre les mises en gardes concernant l'impact sur la santé de certains comportements comme fumer, ne pas faire assez d'exercice et boire trop ?

---

<b>10</b>	<b>En:</b> ...understand information about recommended health screenings or examinations? (Ex. colorectal cancer screening, blood sugar test)
	<b>Fr :</b> ...comprendre les informations sur les dépistages et examens recommandés ? (Par ex. dépistage du cancer colorectal, test de glycémie)

---

	<b>En:</b> ...judge if the information on health risks in the mass media is reliable? (Ex. Newspapers, TV or Internet)
<b>11</b>	<b>Fr :</b> ...évaluer la fiabilité des informations disponibles dans les médias sur ce qui est dangereux pour la santé ? (Par ex. journaux, télévision ou internet)

---

	<b>En:</b> ...decide how you can protect yourself from illness using information from the mass media? (Ex. Newspapers, TV or Internet)
<b>12</b>	<b>Fr :</b> ...savoir comment vous protéger des maladies à partir des informations disponibles dans les médias ? (Par ex. journaux, télévision ou internet)

---

<b>13</b>	<b>En:</b> ...find information about activities that are good for your mental health and well-being? (Ex. relaxation, physical exercise, yoga)
	<b>Fr :</b> ...vous renseigner sur les activités bénéfiques pour votre santé et votre bien être ? (Par ex. relaxation, exercice physique, yoga)

---

<b>14</b>	<b>En:</b> ...understand advice concerning your health from family or friends?
	<b>Fr :</b> ...comprendre les conseils de votre famille ou de vos amis en matière de santé ?

---

<b>15</b>	<b>En:</b> ...understand information in the media on how to get healthier?
	<b>Fr :</b> ...comprendre les informations disponibles dans les médias pour être en meilleure santé ?

---

<b>16</b>	<b>En:</b> ...judge which everyday behavior is related to your health?
	<b>Fr :</b> ...identifier quels sont les comportements de votre vie de tous les jours qui ont un impact sur votre santé ?

---



**S4 Table.** Responses distribution to the 10 items of the Health Literacy for School-Aged Children (HLSAC) according to the grade – N (%)

		8 <sup>th</sup> grade	9 <sup>th</sup> grade	11 <sup>th</sup> & 12 <sup>th</sup> grades – vocational school	11 <sup>th</sup> grade – general school	Total
	N	357	387	285	415	1444
HSLAC_1	Not at all true	12 (3.4)	9 (2.3)	14 (4.9)	6(1.4)	41 (2.8)
	Not completely true	37 (10.4)	41 (10.6)	56 (19.6)	60 (14.5)	194 (13.4)
	Somewhat true	228 (63.9)	269 (69.5)	162 (56.4)	291 (70.1)	950 (65.8)
	Absolutely true	74 (20.7)	62 (16.0)	40 (14.0)	56 (13.5)	232 (16.1)
	Missing	6 (1.7)	6 (1.6)	13 (4.6)	2 (0.5)	27 (1.9)
HSLAC_2	Not at all true	19 (5.3)	30 (7.8)	29 (10.2)	18 (4.3)	96 (6.7)
	Not completely true	75 (21.0)	88 (22.7)	57 (20.0)	81 (19.5)	301 (20.8)
	Somewhat true	205 (57.4)	207 (53.5)	138 (48.4)	238 (57.3)	788 (54.6)
	Absolutely true	49 (13.7)	54 (13.9)	47 (16.5)	74 (17.8)	224 (15.5)
	Missing	9 (2.5)	8 (2.1)	14 (4.9)	4 (1.0)	35 (2.4)
HSLAC_3	Not at all true	26 (7.3)	25 (6.5)	24 (8.4)	14 (3.4)	89 (6.2)
	Not completely true	80 (22.4)	81 (20.9)	40 (14.0)	64 (15.4)	265 (18.3)
	Somewhat true	169 (47.3)	204 (52.7)	158 (55.4)	252 (60.7)	783 (54.2)
	Absolutely true	69 (19.3)	67 (17.3)	50 (17.5)	83 (20.0)	269 (18.6)
	Missing	13 (3.6)	10 (2.6)	13 (4.6)	2 (0.5)	38 (2.6)
HSLAC_4	Not at all true	2 (0.6)	4 (1.0)	6 (2.1)	4 (1.0)	16 (1.1)
	Not completely true	19 (5.3)	9 (2.3)	17 (6.0)	11 (2.6)	56 (3.9)
	Somewhat true	131 (36.7)	134 (34.6)	117 (41.0)	146 (35.2)	528 (36.6)
	Absolutely true	195 (54.6)	231 (59.7)	132 (46.3)	252 (60.7)	810 (56.1)
	Missing	10 (2.8)	9 (2.3)	13 (4.6)	2 (0.5)	34 (2.3)
HSLAC_5	Not at all true	13 (3.6)	7 (1.8)	9 (3.2)	2 (0.5)	31 (2.1)
	Not completely true	40 (11.2)	41 (10.6)	21 (7.4)	32 (7.7)	134 (9.3)
	Somewhat true	167 (46.8)	187 (48.3)	153 (53.7)	179 (43.1)	686 (47.5)
	Absolutely true	123 (34.4)	143 (36.9)	86 (30.2)	199 (47.9)	551 (38.2)
	Missing	14 (3.9)	9 (2.3)	16 (5.6)	3 (0.7)	42 (2.9)
HSLAC_6	Not at all true	19 (5.3)	14 (3.6)	12 (4.2)	7 (1.7)	52 (3.6)
	Not completely true	52 (14.6)	58 (15.0)	47 (16.5)	41 (9.9)	198 (13.7)
	Somewhat true	150 (42.0)	177 (45.7)	128 (44.9)	195 (47.0)	650 (45.0)
	Absolutely true	124 (34.7)	127 (32.8)	84 (29.5)	170 (41.0)	505 (35.0)
	Missing	12 (3.4)	11 (2.8)	14 (4.9)	2 (0.5)	39 (2.7)
HSLAC_7	Not at all true	14 (3.9)	15 (3.9)	6 (2.1)	1 (0.2)	36 (2.5)
	Not completely true	62 (17.4)	52 (13.4)	36 (12.6)	50 (12.0)	200 (13.8)
	Somewhat true	185 (51.8)	219 (56.6)	166 (58.3)	267 (64.3)	837 (58.0)
	Absolutely true	82 (23.0)	91 (23.5)	62 (21.7)	94 (22.6)	329 (22.8)
	Missing	14 (3.9)	10 (2.6)	15 (5.3)	3 (0.7)	42 (2.9)
HSLAC_8	Not at all true	18 (5.0)	18 (4.6)	15 (5.3)	9 (2.2)	60 (4.2)
	Not completely true	51 (14.3)	54 (13.9)	38 (13.3)	45 (10.8)	188 (13.0)
	Somewhat true	174 (48.7)	192 (49.6)	125 (43.9)	207 (49.9)	698 (48.3)
	Absolutely true	102 (28.6)	110 (28.4)	91 (31.9)	152 (36.6)	455 (31.5)
	Missing	12 (3.4)	13 (3.4)	16 (5.6)	2 (0.5)	43 (3.0)
HSLAC_9	Not at all true	25 (7.0)	22 (5.7)	27 (9.5)	19 (4.6)	93 (6.4)
	Not completely true	85 (23.8)	85 (22.0)	68 (23.9)	113 (27.2)	351 (24.3)
	Somewhat true	161 (45.1)	223 (57.6)	135 (47.4)	229 (55.2)	748 (51.8)
	Absolutely true	74 (20.7)	44 (11.4)	41 (14.4)	50 (12.0)	209 (14.5)
	Missing	12 (3.4)	13 (3.4)	14 (4.9)	4 (1.0)	43 (3.0)
HSLAC_10	Not at all true	20 (5.6)	18 (4.6)	24 (8.4)	11 (2.6)	73 (5.1)
	Not completely true	60 (16.8)	73 (18.9)	46 (16.1)	57 (13.7)	236 (16.3)
	Somewhat true	184 (51.4)	199 (51.4)	133 (46.7)	224 (54.0)	740 (51.2)
	Absolutely true	80 (22.4)	86 (22.2)	69 (24.2)	120 (28.9)	355 (24.6)
	Missing	13 (3.6)	11 (2.8)	13 (4.6)	3 (0.7)	40 (2.8)

**S4 Table bis.** Responses distribution to the 15 items of the Health Literacy Assessment Scale for Adolescents (HAS-A) according to the grade – N (%)

		8 <sup>th</sup> grade	9 <sup>th</sup> grade	11 <sup>th</sup> & 12 <sup>th</sup> grades – vocational school	11 <sup>th</sup> grade – general school	Total
N		357	387	285	415	1444
HAS-A_1	Never	80 (22.4)	91 (23.5)	86 (30.2)	73 (17.6)	330 (22.9)
	Rarely	110 (30.8)	126 (32.6)	80 (28.1)	134 (32.3)	450 (31.2)
	Sometimes	102 (28.6)	115 (29.7)	74 (26.0)	129 (31.1)	420 (29.1)
	Often	49 (13.7)	36 (9.3)	33 (11.6)	56 (13.5)	174 (12.0)
	Always	11 (3.1)	14 (3.6)	8 (2.8)	22 (5.3)	55 (3.8)
	Missing	5 (1.4)	5 (1.3)	4 (1.4)	1 (0.2)	15 (1.0)
HAS-A_2	Never	13 (3.6)	13 (3.4)	18 (6.3)	13 (3.1)	57 (3.9)
	Rarely	22 (6.2)	17 (4.4)	19 (6.7)	16 (3.9)	74 (5.1)
	Sometimes	43 (12.0)	40 (10.3)	43 (15.1)	52 (12.5)	178 (12.3)
	Often	139 (38.9)	125 (32.3)	87 (30.5)	167 (40.2)	518 (35.9)
	Always	134 (37.5)	183 (47.3)	114 (40.0)	160 (38.5)	591 (40.9)
	Missing	6 (1.7)	9 (2.3)	4 (1.4)	7 (1.7)	26 (1.8)
HAS-A_3	Never	15 (4.2)	11 (2.8)	14 (4.9)	9 (2.2)	49 (3.4)
	Rarely	32 (9.0)	42 (10.8)	28 (9.8)	51 (12.3)	153 (10.6)
	Sometimes	70 (19.6)	79 (20.4)	64 (22.5)	83 (20.0)	296 (20.5)
	Often	122 (34.2)	132 (34.1)	85 (29.8)	170 (41.0)	509 (35.2)
	Always	108 (30.2)	116 (30.0)	89 (31.2)	97 (23.4)	410 (28.4)
	Missing	10 (2.8)	7 (1.8)	5 (1.7)	5 (1.2)	27 (1.9)
HAS-A_4	Never	8 (2.2)	3 (0.8)	10 (3.5)	4 (1.0)	25 (1.7)
	Rarely	17 (4.8)	12 (3.1)	11 (3.9)	11 (2.6)	51 (3.5)
	Sometimes	62 (17.4)	47 (12.1)	46 (16.0)	63 (15.2)	218 (15.1)
	Often	123 (34.4)	163 (42.1)	96 (33.7)	175 (42.2)	557 (38.6)
	Always	140 (39.2)	156 (40.3)	118 (41.4)	159 (38.3)	573 (39.7)
	Missing	7 (2.0)	6 (1.5)	4 (1.4)	3 (0.7)	20 (1.4)
HAS-A_5	Never	7 (2.0)	7 (1.8)	8 (2.8)	3 (0.7)	25 (1.7)
	Rarely	16 (4.5)	13 (3.4)	9 (3.1)	16 (3.9)	54 (3.7)
	Sometimes	67 (18.8)	76 (19.6)	60 (21.1)	68 (16.4)	271 (18.8)
	Often	137 (38.4)	155 (40.0)	116 (40.7)	198 (47.7)	606 (42.0)
	Always	125 (35.0)	128 (33.1)	85 (29.6)	127 (30.6)	465 (32.2)
	Missing	5 (1.4)	8 (2.1)	7 (2.5)	3 (0.7)	23 (1.6)
HAS-A_6	Never	102 (28.6)	94 (24.3)	62 (21.8)	61 (14.7)	319 (22.1)
	Rarely	84 (23.5)	103 (26.6)	59 (20.7)	96 (23.1)	342 (23.7)
	Sometimes	100 (28.0)	112 (28.9)	88 (30.9)	158 (38.1)	458 (31.7)
	Often	48 (13.4)	56 (14.5)	49 (17.2)	80 (19.3)	233 (16.1)
	Always	15 (4.2)	12 (3.1)	18 (6.3)	17 (4.1)	62 (4.3)
	Missing	8 (2.2)	10 (2.6)	9 (3.2)	3 (0.7)	30 (2.1)
HAS-A_7	Never	167 (46.8)	183 (47.3)	113 (39.6)	145 (34.9)	608 (42.1)
	Rarely	100 (28.0)	99 (25.6)	75 (26.3)	163 (39.3)	437 (30.3)
	Sometimes	53 (14.9)	61 (15.8)	62 (21.7)	70 (16.9)	246 (17.0)
	Often	19 (5.3)	28 (7.2)	23 (8.1)	30 (7.2)	100 (6.9)
	Always	9 (2.5)	9 (2.3)	6 (2.1)	5 (1.2)	29 (2.0)
	Missing	9 (2.5)	7 (1.8)	6 (2.1)	2 (0.5)	24 (1.7)
HAS-A_8	Never	140 (39.2)	171 (44.2)	112 (39.3)	150 (36.1)	573 (39.7)
	Rarely	95 (26.6)	99 (25.6)	68 (23.9)	145 (34.9)	407 (28.2)
	Sometimes	74 (20.7)	66 (17.0)	49 (17.2)	72 (17.3)	261 (18.1)
	Often	28 (7.8)	30 (7.7)	32 (11.2)	34 (8.2)	124 (8.6)
	Always	9 (2.5)	13 (3.4)	15 (5.3)	10 (2.4)	47 (3.2)
	Missing	11 (3.1)	8 (2.1)	9 (3.2)	4 (1.0)	32 (2.2)

S4 Table bis. Continued

HAS-A_9	Never	161 (45.1)	174 (45.0)	132 (46.3)	154 (37.1)	623 (43.0)
	Rarely	82 (23.0)	90 (23.3)	44 (15.4)	129 (31.1)	345 (23.9)
	Sometimes	68 (19.0)	68 (17.6)	45 (15.8)	59 (14.2)	240 (16.6)
	Often	25 (7.0)	30 (7.7)	32 (11.2)	58 (14.0)	145 (10.0)
	Always	11 (3.1)	17 (4.4)	25 (8.8)	13 (3.1)	66 (4.6)
	Missing	10 (2.8)	8 (2.1)	7 (2.5)	2 (0.5)	27 (1.9)
HAS-A_10	Never	154 (43.1)	164 (42.4)	109 (38.2)	128 (30.8)	555 (38.4)
	Rarely	86 (24.1)	111 (28.7)	75 (26.3)	140 (33.7)	412 (28.5)
	Sometimes	64 (17.9)	67 (17.3)	51 (17.9)	95 (22.9)	277 (19.2)
	Often	29 (8.1)	22 (5.7)	25 (8.8)	39 (9.4)	115 (8.0)
	Always	19 (5.3)	18 (4.6)	19 (6.7)	11 (2.6)	67 (4.6)
	Missing	5 (1.4)	5 (1.3)	6 (2.1)	2 (0.5)	18 (1.2)
HAS-A_11	Never	130 (36.4)	145 (37.5)	86 (30.2)	97 (23.4)	458 (31.7)
	Rarely	100 (28.0)	121 (31.3)	78 (27.4)	150 (36.1)	449 (31.1)
	Sometimes	78 (21.8)	88 (22.7)	75 (26.3)	119 (28.7)	360 (24.9)
	Often	33 (9.2)	20 (5.2)	24 (8.4)	38 (9.2)	115 (8.0)
	Always	7 (2.0)	7 (1.8)	14 (4.9)	7 (1.7)	35 (2.4)
	Missing	9 (2.5)	6 (1.5)	8 (2.8)	4 (1)	27 (1.9)
HAS-A_12	Never	139 (38.9)	146 (37.7)	93 (32.6)	136 (32.8)	514 (35.6)
	Rarely	106 (29.7)	123 (31.8)	98 (34.4)	155 (37.3)	482 (33.4)
	Sometimes	61 (17.1)	79 (20.4)	52 (18.2)	84 (20.2)	276 (19.1)
	Often	25.0 (7.0)	27 (7.0)	24 (8.4)	30 (7.2)	106 (7.3)
	Always	12 (3.4)	6 (1.5)	12 (4.2)	7 (1.7)	37 (2.6)
	Missing	14 (3.9)	6 (1.5)	6 (2.1)	3 (0.7)	29 (2.0)
HAS-A_13	Never	92 (25.8)	111 (28.7)	57 (20.0)	102 (24.6)	362 (25.1)
	Rarely	89 (24.9)	86 (22.2)	56 (19.6)	139 (33.5)	370 (25.6)
	Sometimes	85 (23.8)	108 (27.9)	83 (29.1)	88 (21.2)	364 (25.2)
	Often	50 (14.0)	56 (14.5)	47 (16.5)	62 (14.9)	215 (14.9)
	Always	28 (7.8)	21 (5.4)	35 (12.3)	22 (5.3)	106 (7.3)
	Missing	13 (3.6)	5 (1.3)	7 (2.5)	2 (0.5)	27 (1.9)
HAS-A_14	Never	125 (35.0)	131 (33.8)	73 (25.6)	90 (21.7)	419 (29.0)
	Rarely	93 (26.0)	110 (28.4)	99 (34.7)	149 (35.9)	451 (31.2)
	Sometimes	85 (23.8)	94 (24.3)	63 (22.1)	133 (32.0)	375 (26.0)
	Often	33 (9.2)	38 (9.8)	21 (7.4)	34 (8.2)	126 (8.7)
	Always	10 (2.8)	9 (2.3)	23 (8.1)	6 (1.4)	48 (3.3)
	Missing	11 (3.1)	5 (1.3)	6 (2.1)	3 (0.7)	25 (1.7)
HAS-A_15	Never	177 (49.6)	203 (52.4)	154 (54.0)	246 (59.3)	780 (54.0)
	Rarely	71 (19.9)	84 (21.7)	56 (19.6)	105 (25.3)	316 (21.9)
	Sometimes	50 (14.0)	61 (15.8)	35 (12.3)	44 (10.6)	190 (13.2)
	Often	34 (9.5)	23 (5.9)	18 (6.3)	12 (2.9)	87 (6.0)
	Always	13 (3.6)	10 (2.6)	15 (5.3)	6 (1.3)	44 (3.0)
	Missing	12 (3.4)	6 (1.5)	7 (2.5)	2 (0.5)	27 (1.9)

**S4 Table ter.** Responses distribution to the 16 items of the European Health Literacy Survey (HLS-EU-Q16) according to the grade – N (%)

		8 <sup>th</sup> grade	9 <sup>th</sup> grade	11 <sup>th</sup> & 12 <sup>th</sup> grades – vocational school	11 <sup>th</sup> grade – general school	Total
	N	357	387	285	415	1444
HLSEU_1	Very easy	93 (26.0)	99 (25.6)	60 (21.1)	111 (26.8)	363 (25.1)
	Easy	195 (54.6)	223 (57.6)	176 (61.8)	258 (62.2)	852 (59.0)
	Difficult	48 (13.4)	52 (13.4)	32 (11.2)	37 (8.9)	169 (11.7)
	Very difficult	5 (1.4)	3 (0.8)	8 (2.8)	0 (0)	16 (1.1)
	Missing	16 (4.5)	10 (2.6)	9 (3.2)	9 (2.2)	44 (3.1)
HLSEU_2	Very easy	175 (49.0)	178 (46.0)	103 (36.1)	211 (50.8)	667 (46.2)
	Easy	150 (42.0)	177 (45.7)	153 (53.7)	174 (41.9)	654 (45.3)
	Difficult	26 (7.3)	28 (7.2)	17 (6.0)	26 (6.3)	97 (6.7)
	Very difficult	2 (0.6)	0 (0)	2 (0.2)	0 (0)	4 (0.3)
	Missing	4 (1.1)	4 (1.0)	10 (3.5)	4 (1.0)	22 (1.5)
HLSEU_3	Very easy	150 (42.0)	140 (36.2)	89 (31.2)	153 (36.9)	532 (36.9)
	Easy	173 (48.5)	212 (54.8)	162 (56.8)	228 (54.9)	775 (53.7)
	Difficult	29 (8.1)	30 (7.7)	19 (6.7)	30 (7.2)	108 (7.5)
	Very difficult	1 (0.3)	2 (0.5)	2 (0.7)	0 (0)	5 (0.3)
	Missing	4 (1.1)	3 (0.8)	13 (4.5)	4 (1.0)	24 (1.7)
HLSEU_4	Very easy	213 (59.7)	228 (58.9)	154 (54.0)	248 (59.8)	843 (58.4)
	Easy	127 (35.6)	145 (37.5)	111 (39.0)	151 (36.4)	534 (37.0)
	Difficult	7 (2.0)	9 (2.3)	11 (3.9)	9 (2.2)	36 (2.5)
	Very difficult	5 (1.4)	1 (0.3)	0 (0)	2 (0.5)	8 (0.6)
	Missing	5 (1.4)	4 (1.0)	9 (3.2)	5 (1.2)	23 (1.6)
HLSEU_5	Very easy	46 (12.9)	69 (17.8)	39 (13.7)	55 (13.3)	209 (14.5)
	Easy	180 (50.4)	164 (42.4)	114 (40.0)	176 (42.4)	634 (43.9)
	Difficult	107 (30.0)	125 (32.3)	107 (37.5)	158 (38.1)	497 (34.4)
	Very difficult	10 (2.8)	18 (4.6)	13 (4.5)	18 (4.3)	59 (4.1)
	Missing	14 (3.9)	11 (2.8)	12 (4.2)	8 (1.9)	45 (3.1)
HLSEU_6	Very easy	99 (27.7)	90 (23.3)	69 (24.2)	91 (21.9)	349 (24.2)
	Easy	174 (48.7)	213 (55.0)	148 (51.9)	232 (55.9)	767 (53.0)
	Difficult	62 (17.4)	62 (16.0)	51 (17.9)	80 (19.3)	255 (17.7)
	Very difficult	8 (2.2)	13 (3.4)	7 (2.5)	6 (1.5)	34 (2.4)
	Missing	14 (3.9)	9 (2.3)	10 (3.5)	6 (1.5)	39 (2.7)
HLSEU_7	Very easy	224 (62.8)	214 (55.3)	145 (50.9)	233 (56.2)	816 (56.5)
	Easy	111 (31.1)	156 (40.3)	115 (40.4)	162 (39.0)	544 (37.7)
	Difficult	13 (3.6)	10 (2.6)	15 (5.3)	13 (3.1)	51 (3.5)
	Very difficult	2 (0.6)	1 (0.3)	1 (0.4)	3 (0.7)	7 (0.5)
	Missing	7 (2.0)	6 (1.5)	9 (3.2)	4 (1.0)	26 (1.8)
HLSEU_8	Very easy	68 (19.0)	78 (20.2)	55 (19.3)	72 (17.4)	273 (18.9)
	Easy	134 (37.5)	136 (35.1)	104 (36.5)	156 (37.6)	530 (36.7)
	Difficult	109 (30.5)	122 (31.5)	88 (30.9)	142 (34.2)	461 (31.9)
	Very difficult	31 (8.7)	41 (10.6)	24 (8.4)	34 (8.2)	130 (9.0)
	Missing	15 (4.2)	10 (2.6)	14 (4.9)	11 (2.7)	50 (3.5)
HLSEU_9	Very easy	223 (62.5)	221 (57.1)	128 (44.9)	235 (56.6)	807 (55.9)
	Easy	107 (30.0)	120 (31.0)	108 (37.9)	145 (34.9)	480 (33.2)
	Difficult	14 (3.9)	31 (8.0)	28 (9.8)	24 (5.8)	97 (6.7)
	Very difficult	6 (1.7)	6 (1.5)	10 (3.5)	7 (1.7)	29 (2.0)
	Missing	7 (2.0)	9 (2.3)	11 (3.9)	4 (1.0)	31 (2.2)

S4 Table ter. Continued

		8 <sup>th</sup> grade	9 <sup>th</sup> grade	11 <sup>th</sup> & 12 <sup>th</sup> grades – vocational school	11 <sup>th</sup> grade – general school	Total
	N	357	387	285	415	1444
HLSEU_10	Very easy	127 (35.6)	157 (40.6)	139 (48.8)	247 (59.5)	670 (46.4)
	Easy	158 (44.3)	153 (39.5)	104 (36.5)	135 (32.5)	550 (38.1)
	Difficult	54 (15.1)	56 (14.5)	28 (9.8)	25 (6.0)	163 (11.3)
	Very difficult	6 (1.7)	15 (3.9)	4 (1.4)	4 (1.0)	29 (2.0)
	Missing	12 (3.4)	6 (1.5)	10 (3.5)	4 (1.0)	32 (2.2)
HLSEU_11	Very easy	97 (27.2)	72 (18.6)	48 (16.8)	60 (14.5)	277 (19.2)
	Easy	156 (43.7)	183 (47.3)	144 (50.5)	178 (42.9)	661 (45.8)
	Difficult	91 (25.5)	107 (27.6)	67 (23.5)	153 (36.9)	418 (28.9)
	Very difficult	6 (1.7)	15 (3.9)	12 (4.2)	20 (4.8)	53 (3.7)
	Missing	7 (2.0)	10 (2.6)	14 (4.9)	4 (1.0)	35 (2.4)
HLSEU_12	Very easy	90 (25.2)	84 (21.7)	75 (26.3)	78 (18.8)	327 (22.6)
	Easy	191 (53.5)	198 (51.2)	137 (48.1)	223 (53.7)	749 (51.9)
	Difficult	61 (17.1)	85 (22.0)	55 (19.3)	94 (22.6)	295 (20.4)
	Very difficult	7 (2.0)	9 (2.3)	6 (2.1)	15 (3.6)	37 (2.6)
	Missing	8 (2.2)	11 (2.8)	12 (4.2)	5 (1.2)	36 (2.5)
HLSEU_13	Very easy	98 (27.4)	87 (22.5)	71 (24.9)	118 (28.4)	374 (25.9)
	Easy	173 (48.5)	188 (48.6)	124 (43.5)	186 (44.8)	671 (46.5)
	Difficult	69 (19.3)	77 (19.9)	62 (21.7)	91 (21.9)	299 (20.7)
	Very difficult	4 (1.1)	23 (5.9)	11 (3.9)	14 (3.4)	52 (3.6)
	Missing	13 (3.6)	12 (3.1)	17 (6.0)	6 (1.4)	48 (3.3)
HLSEU_14	Very easy	201 (56.3)	179 (46.3)	112 (39.3)	180 (43.4)	672 (46.5)
	Easy	129 (36.1)	175 (45.2)	129 (45.3)	197 (47.5)	630 (43.6)
	Difficult	17 (4.8)	23 (5.9)	28 (9.8)	28 (6.7)	96 (6.6)
	Very difficult	2 (0.6)	4 (1.0)	6 (2.1)	6 (1.4)	18 (1.2)
	Missing	8 (2.2)	6 (1.5)	10 (3.5)	4 (1.0)	28 (1.9)
HLSEU_15	Very easy	105 (29.4)	102 (26.4)	65 (22.8)	93 (22.4)	365 (25.3)
	Easy	187 (52.4)	216 (55.8)	143 (50.2)	241 (58.1)	787 (54.5)
	Difficult	46 (12.9)	55 (14.2)	60 (21.0)	70 (16.9)	231 (16.0)
	Very difficult	9 (2.5)	6 (1.5)	7 (2.5)	6 (1.4)	28 (1.9)
	Missing	10 (2.8)	8 (2.1)	10 (3.5)	5 (1.2)	33 (2.3)
HLSEU_16	Very easy	111 (31.1)	120 (31.0)	80 (28.1)	133 (32.0)	444 (30.7)
	Easy	158 (44.3)	167 (43.1)	135 (47.4)	184 (44.3)	644 (44.6)
	Difficult	64 (17.9)	71 (18.3)	47 (16.5)	73 (17.6)	255 (17.7)
	Very difficult	14 (3.9)	20 (5.2)	12 (4.2)	16 (3.9)	62 (4.3)
	Missing	10 (2.8)	9 (2.3)	11 (3.9)	9 (2.2)	39 (2.7)