PLANETARY-HEALTH LITERACY AND MENTAL WELLBEING IN CZECH ADOLESCENTS: INSIGHTS FROM THE HBSC SURVEY 2022

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SUMMARY

Objectives: Planetary-health literacy (PHL), the knowledge, motivation and social support required to safeguard both human and environmental health, may help adolescents cope with climate-related distress and adopt sustainable behaviours. Evidence on the linkage between PHL and mental health from Central and Eastern Europe is lacking. The aim of the study was to describe PHL in Czech adolescents by sex, grade and family affluence, examine its association with mental-health indicators, and explore links with selected environment-relevant behaviours.

Methods: Cross-sectional data were drawn from the nationally representative Health Behaviour in School-aged Children (HBSC) 2022 survey (n = 4,195, 50.8% boys, ages 13 and 15 years). PHL was measured with an 11-item HBSC optional package yielding three sub-scales (knowledge, action, perceived pro-environmental social norms). Outcomes were wellbeing (WHO-5), life satisfaction (Cantril's ladder), and psychological complaints (HBSC symptom checklist). Fruit and vegetable intake plus cigarette and e-cigarette use served as behavioural correlates.

Results: Girls scored higher than boys on all PHL domains (Cohen d = 0.10–0.19). Thirteen-year-olds reported more action and stronger social norms than fifteen-year-olds ($p < 0.001$); socioeconomic gradients were small. In fully adjusted models, social norms were positively associated with wellbeing (β = 1.42, 95% CI: 1.12–1.72) and life satisfaction (β = 0.10, 0.08–0.13), and inversely with psychological complaints (β = −0.27, −0.33 to −0.21). Knowledge showed weak adverse relations with wellbeing and complaints, whereas action was associated with wellbeing only. Higher PHL related to daily fruit and vegetable consumption and inversely to intensive e-cigarette use; effect sizes were modest.

Conclusions: Perceived pro-environmental social norms appear most tightly related to adolescent mental health, while overall PHL is slightly associated with sustainable dietary patterns and lower use of e-cigarettes. School curricula that combine climate education with collaborative, action-oriented projects may therefore deliver co-benefits for planetary and psychological health in Central and Eastern Europe.

Key words: planetary-health literacy, adolescents, wellbeing, social norms, HBSC, Czechia

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INTRODUCTION

Planetary health, defined as "the health of human civilisation and the state of the natural systems on which it depends" (1), has recently emerged as a unifying framework for public-health action. The framework recognizes that ongoing climate change, biodiversity loss and other forms of environmental degradation negatively affect not only health of our ecosystem, but also physical as well as psychological health of humans. The accelerating changes therefore raise concerns about increase in population mental health burden in coming decades (2, 3).

Adolescents are uniquely vulnerable group to these threats. They are undergoing a period of rapid biological and social transitions, while facing an uncertain ecological future. This experience can manifest as climate-related distress, anxiety and depressive symptoms (4). A growing body of reviews, including a scoping review focused on children population and a recent systematic review of eco-anxiety and mental-health outcomes, conclude that eco-anxiety and related emotions are already common among children and young people worldwide (5, 6). Large cross-sectional data from the USA show that more than three quarters of adolescents and young adults are at least moderately worried about climate change and many report sadness, fear/helplessness or anger in response (7). Such emotional responses, if left unaddressed amid limited access to appropriate youth mental-health care, risk compromising developmental trajectories and widening existing inequalities in mental health (8, 9). Protecting the mental health of adolescents during the ongoing climate crisis is crucial for their healthy development. Understanding their knowledge, attitudes, behaviours and characteristics associated with different views on climate change is therefore an important prerequisite for shaping appropriate and well targeted public health interventions.

Planetary-health literacy (PHL) has been proposed as a construct that integrates knowledge about environmental problems,

action and perceived social norms supportive of sustainability (10, 11). In this study, planetary-health literacy refers to adolescents' knowledge about links between environmental change and human health, self-reported effort to act, and perceived pro-environmental social norms in their immediate environment.

Higher PHL could be linked with pro-environmental behaviour, however, association can be modest. Social-norms research further indicates that perceiving peers as climate-friendly can strengthen personal norms and promote adaptive coping with environmental threats. However, if the PHL also relates to mental-health outcomes, such as life satisfaction, general wellbeing and psychosomatic complaints, remains understudied, especially in Central and Eastern Europe.

To address this gap, the 2021/22 Health Behaviour in School-aged Children (HBSC) survey introduced a new 11-item optional package on planetary health, derived from three validated instruments (Sustainability Consciousness Questionnaire, Environmental Literacy Instrument for Adolescents, and Australian Climate Change Perceptions Scale) (10, 12, 17). The package measures three sub-scales of PHL: knowledge (5 items), action (3 items) and perceived pro-environmental social norms (3 items), and provides nationally representative cross-sectional data on adolescent PHL together with already established HBSC indicators of mental health.

Because knowledge does not automatically translate into action, we conducted a secondary analysis that looked at the association of the planetary-health score and selected behaviours that have clear environmental footprints and which are captured in the HBSC questionnaire. As HBSC does not include a comprehensive battery of pro-environmental behaviours, we decided to explore a small set of available health-related behaviours that may be viewed as relevant to planetary health via potential co-benefits (diet quality, nicotine-related consumption). Higher fruit and vegetable intake serves as a proxy for a more plant-based dietary pattern, which is widely recognised as one of the most effective individual-level mitigation strategies for reducing greenhouse-gas emissions, land use and other environmental impacts of our food system (13, 14). It could be expected that adolescents with higher planetary-health score should adopt these dietary patterns. Conversely, both cigarette smoking and the use of disposable e-cigarettes generate substantial plastic, chemical and battery waste and are now acknowledged sources of pollution (15). In line with this, environmentally conscious adolescents would avoid these products. By examining whether adolescents who score higher on planetary-health score also report these potentially environment-relevant behaviours accordingly to their higher knowledge, action or social norms, we are at least partially able to provide some form of behavioural correlates of the self-reported planetary-health score and see, whether the self-reported scales of planetary health are reflected in everyday lifestyle choices with real environmental consequences. However, the available indicators are imperfect. Fruit and vegetable intake does not directly measure animal-source food consumption, and the nicotine items do not distinguish disposable from rechargeable e-cigarette. Therefore, findings must be interpreted with caution.

Using HBSC 2022 data from Czechia, this study aims to describe the distribution of PHL sub-scales by sex, grade, and family affluence, examine their associations with three mental-health outcomes (wellbeing, life satisfaction and psychological complaints) and explore their links with selected health-related and environmentally sensitive behaviours. Presented findings aim to inform future educational and public-health strategies targeting psychological wellbeing and climate change resilience of the next generation.

MATERIALS AND METHODS

Study Sample and Design

Data for analyses were retrieved from the Czech HBSC study, a cross-national research project conducted every four years in collaboration with the World Health Organization (16). The HBSC study collects self-reported data on health and health-behaviours such as physical activity, diet and family affluence, from adolescents aged 11, 13 and 15 years. It follows a standardized methodology to ensure consistency and reliability across all data collection. This study involved Czech adolescents from 2022 survey wave. Data were drawn from the representative national sample, with participants selected by a cluster sampling approach in accordance with HBSC survey protocols. Across all 14 administrative regions, 246 schools participated in the survey and number of respondents with valid questionnaires totalled at 14,588. The data were collected using a self-completed questionnaire distributed in the classroom to students in 5th, 7th and 9th grades. However, the PHL scale was implemented only in one version of the questionnaire for 7th and 9th graders, i.e., 13- and 15-year-olds. The final sample used in this study consisted of 4,195 adolescents (50.8% boys), including 1,836 aged 13 and 2,359 aged 15. Participants' parents/guardians were notified about the study through the school and given the option to exclude their children out from participation. The Institutional Ethics Committee for Research of the Faculty of Physical Culture of Palacký University Olomouc approved the research protocol (reg. no. 14/2019). The pupil response rate was 86.1% at the school level and 83.1% at the level of individuals.

Socioeconomic Status Measure

The HBSC Family Affluence Scale (FAS), a validated measure of family income and material wealth, was used to assess SES of participants' families. The FAS was calculated using questions about household assets and material conditions. In the 2022 survey, the FAS was based on responses as follows: car ownership (no = 0, one = 1, two or more = 2), having own bedroom (no = 0, yes = 1), computer ownership (none = 0, one = 1, two = 2, three or more = 3), and family holidays in the past year (never = 0, once = 1, twice = 2, three or more times = 3), dishwasher ownership (no = 0, yes = 1) and the number of bathrooms (none = 0, one = 1, two = 2, three or more = 3). A summary score was calculated by summing all the FAS-related responses. This score was then categorized into the lowest 20% (low SES), middle 60% (medium SES), and highest 20% (high SES).

Planetary-health Literacy Score

Planetary-health literacy was assessed with the HBSC Planetary Health optional package introduced in the 2021/22 survey cycle. The package comprises 11 Likert-type items drawn from

three previously validated instruments: Environmental Literacy Instrument for Adolescents (12), Sustainability Consciousness Questionnaire (10), and Australian Climate-Change Perceptions Scale (17). Items are answered on a 5-point scale ranging from 0 = strongly disagree to 4 = strongly agree.

Three subscale scores were computed, with higher values indicating stronger planetary-health literacy:

Knowledge (5 items, range = 0–20): beliefs about the necessity of biodiversity conservation, renewable resources, waste reduction, water conservation and stricter environmental regulation. The domain included questions like "Preserving the diversity of living species is necessary for sustainable development (preserving biodiversity)." or "Sustainable development requires that people reduce the amount of all types of waste."

Action (3 items, range = 0–12): self-reported effort to adhere to environmental conscious behaviour, preference for environment-related school assignments and lifestyle changes enacted to protect the environment. Example questions are "At the present time, I am actively looking for ways to solve environmental problems." or "I have changed my personal lifestyle to protect the environment."

Perceived pro-environmental social norms (3 items, range = 0–12): perceptions that one's school, family and friends are environmentally friendly. The domain contained questions like "I feel that my school is environmentally friendly." or "My friends are environmentally friendly."

Exploratory and confirmatory factor analyses conducted by the HBSC Planetary-Health working group support a three-factor structure with acceptable model fit ($\chi^2/df = 2.50$, CFI = 0.956, RMSEA = 0.063) and satisfactory internal consistency in multinational pilot data (Cronbach's $\alpha = 0.71–0.80$ across subscales). Internal consistency in the Czech 2022 sample was good ($\alpha = 0.79$ overall; 0.78, 0.74 and 0.72 for knowledge, action and norms, respectively).

Behavioural Outcomes

As a secondary objective, we examined whether adolescents who score higher on the planetary-health scale also report selected environmentally relevant behaviours that are captured in the HBSC questionnaire, namely frequent fruit and vegetable intake and the use of cigarettes or e-cigarettes. Empirical studies often find weak or inconsistent links between knowledge and action, a gap sometimes referred to as the "value-action" or "knowledge-behaviour" paradox (18, 19). At the same time, as questions in PHL questionnaire are based on self-evaluation of knowledge, action and social norms, even weak association with behavioural outcomes could serve as a secondary confirmation of information reported in PHL domains.

Statistical Analysis

Descriptive statistics were used to summarize sample characteristics and environmental-health literacy scores by sex, age group (7th vs. 9th grade), socioeconomic status (FAS), and municipality size. Between-group differences were tested using Welch t-test or ANOVA, with effect sizes reported as Cohen's d or eta squared, respectively.

Associations between PHL domains and self-reported mental health outcomes (wellbeing, life satisfaction, psychological complaints) were examined using a series of multivariate linear regression models. Models were first estimated unadjusted (model 1), then adjusted for sex, grade, and FAS (model 2). To examine potential moderation by sex, interaction terms between sex and the PHL subscales were added to the adjusted model (model 3). To investigate behavioural correlates of PHL, Spearman correlation coefficients were computed to assess the associations between PHL domains and selected health-related behaviours (fruit and vegetable consumption, cigarette and e-cigarette use). All analyses were performed using R version 4.3.0 (R Foundation for Statistical Computing, Vienna, Austria), with statistical significance set at $p < 0.05$.

RESULTS

Planetary-health Literacy by Sex, Age and Socioeconomic Status

Table 1 shows mean scores (±SD) for the three PHL domains. Girls scored higher than boys on knowledge (13.4 ± 4.5 vs. 12.3 ± 5.0), action (5.5 ± 2.9 vs. 4.9 ± 3.2) and pro-environmental social norms (7.3 ± 2.6 vs. 7.0 ± 2.9); all $p \leq 0.002$, but recorded effect sizes were generally weak (Cohen's $d \leq 0.22$). Thirteen-year-olds reported slightly more action and stronger social norms than 15-year-olds (both $p < 0.001$), whereas knowledge did not significantly differ by grade. Small but statistically significant association was observed for family affluence ($p \leq 0.004$), with adolescents from medium- and high-affluence homes scoring higher on all three domains. No association was found with the size of municipality.

Associations with Mental-health Outcomes

Table 2 summarizes multivariate linear-regression models for unadjusted and adjusted association between PHL scores and self-reported mental health.

Wellbeing (WHO-5, 0–100). In the fully adjusted model, higher social-norms scores were associated with better wellbeing ($\beta = 1.42$, 95% CI: 1.12–1.72), whereas higher knowledge correlated with lower wellbeing ($\beta = -0.26$, 95% CI: −0.43 to −0.09). Action showed a positive association ($\beta = 0.52$, 95% CI: 0.28–0.77). A significant sex × social-norms interaction ($\beta = 0.57$, $p = 0.025$) indicated that the wellbeing benefit of supportive norms was stronger among girls. The interaction between perceived social norms and sex is visualized in Figure 1.

Life satisfaction (Cantril's ladder, 0–10). Social norms remained positively associated with reported life satisfaction even after adjustment ($\beta = 0.10$, 95% CI: 0.08–0.13), whereas association with knowledge and action became non-significant. The interaction between sex and social norms was small but significant ($\beta = 0.05$, $p = 0.015$), with larger effects among girls. The interaction is visualized in Figure 2.

Psychological complaints (HBSC symptom checklist, 0–16). Higher social-norms scores were negatively associated with the frequency of psychological complaints ($\beta = -0.27$, 95% CI: −0.33 to −0.21). Greater knowledge score was associated with more frequent psychological complaints ($\beta = 0.07$, 95% CI: 0.04–0.10), while no association was found with action. The interaction between sex and psychological complaints are shown in Figure 3.

Table 1. *Planetary-health literacy mean score and standard deviation across participants characteristics (N = 4,195)*

	Total[c] n (%)	Knowledge n = 3,995 Mean (SD)	Action n = 4,074 Mean (SD)	Social norms n = 4,100 Mean (SD)
Sex				
Boys	2,131 (50.8)	12.30 (5.00)	4.88 (3.23)	6.99 (2.86)
Girls	2,064 (49.2)	13.35 (4.46)	5.46 (2.94)	7.26 (2.59)
p-value		< 0.001	< 0.001	0.002
Effect size[a]		0.22	0.19	0.1
Age				
13-year-olds	1,836 (43.8)	12.90 (4.86)	5.46 (3.21)	7.34 (2.85)
15-year-olds	2,359 (56.2)	12.75 (4.71)	4.95 (3.00)	6.96 (2.63)
p-value		0.35	< 0.001	< 0.001
Effect size[a]		0.03	0.16	0.14
Family Affluence Score				
Low	828 (20.0)	12.25 (5.03)	4.85 (3.12)	6.76 (2.79)
Mid	2,556 (61.8)	13.01 (4.66)	5.27 (3.04)	7.19 (2.67)
High	755 (18.2)	12.77 (4.86)	5.19 (3.30)	7.30 (2.88)
p-value		< 0.001	0.004	< 0.001
Effect size[b]		0.004	0.003	0.005
Size of municipality				
< 2,000	287 (6.8)	12.62 (4.88)	5.26 (3.19)	7.13 (2.93)
2,000–9,900	1,386 (33.0)	12.68 (4.68)	5.07 (3.05)	7.17 (2.78)
10,000–100,000	1,874 (44.7)	12.87 (4.79)	5.20 (3.13)	7.14 (2.68)
> 100,000	648 (15.4)	13.04 (4.89)	5.26 (3.11)	6.99 (2.70)
p-value		0.388	0.523	0.57
Effect size[b]		0	0	0

[a]Cohen's d; [b]eta squared; [c]total sample includes participants with complete data on at least one PHL subscale.

Table 2. *Association between environmental planetary-health subscales score (independent variables) and mental health (dependent variables)*

	Model 1		Model 2		Model 3	
	ß (95% CI)	p-value	ß (95% CI)	p-value	ß (95% CI)	p-value
Wellbeing						
Knowledge	−0.41 (−0.59; −0.23)	< 0.001	−0.26 (−0.43; −0.09)	0.002	−0.25 (−0.42; −0.08)	0.004
Action	0.37 (0.11; 0.63)	0.005	0.52 (0.28; 0.77)	< 0.001	0.53 (0.28; 0.78)	< 0.001
Social norms	1.5 (1.22; 1.85)	< 0.001	1.42 (1.12; 1.72)	< 0.001	1.16 (0.79; 1.54)	< 0.001
Social norms * sex					0.57 (0.07; 1.06)	0.025
Life satisfaction						
Knowledge	−0.02 (−0.03; 0.00)	0.027	−0.01 (−0.02; 0.01)	0.406	−0.01 (-0.02; 0.01)	0.520
Action	0.01 (−0.01; 0.03)	0.327	0.02 (0.00; 0.04)	0.093	0.02 (0.00; 0.04)	0.086
Social norms	0.11 (0.09; 0.14)	< 0.001	0.10 (0.08; 0.13)	< 0.001	0.08 (0.05; 0.11)	< 0.001
Social norms * sex					0.05 (0.01; 0.10)	0.015
Psychological complaints						
Knowledge	0.10 (0.07; 0.14)	< 0.001	0.07 (0.04; 0.10)	< 0.001	0.07 (0.03; 0.10)	< 0.001
Action	0.02 (−0.03; 0.08)	0.362	−0.01 (−0.06; 0.04)	0.794	−0.01 (−0.06; 0.04)	0.773
Social norms	−0.29 (−0.36; −0.23)	< 0.001	−0.27 (−0.33; −0.21)	< 0.001	−0.23 (−0.31; −0.16)	< 0.001
Social norms * sex					−0.08 (−0.18; 0.01)	0.090

Linear regression analysis; CI – confidence interval; wellbeing measured by WHO5 wellbeing index; life satisfaction measured by Cantril's ladder; psychological complaints measured by HBSC symptom checklist; model 1 – unadjusted model; model 2 – adjusted for sex, grade and Family Affluence Score; model 3 – model 2 + interaction terms for sex
While all interaction effects with sex were tested, only those involving the social norms subscale are presented, as all other effects were non-significant.

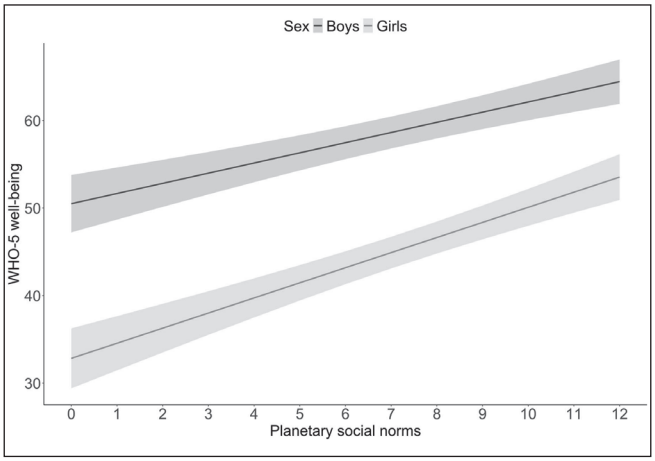

Fig. 1. *Predicted wellbeing (WHO-5 score) by perceived planetary social norms and sex (model 3).*

Lines represent adjusted predicted values across the observed range of perceived social norms; shaded areas indicate 95% confidence intervals. Predictions are based on the fully adjusted regression models, with other covariates (grade, family affluence, and other PHL domains) held constant. Shaded areas represent 95% confidence intervals.

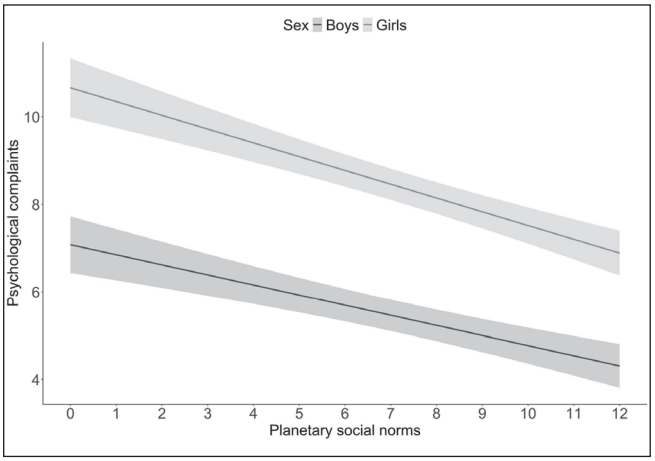

Fig. 3. *Predicted psychological complaints by perceived planetary social norms and sex (model 3).*

Lines represent adjusted predicted values across the observed range of perceived social norms; shaded areas indicate 95% confidence intervals. Predictions are based on the fully adjusted regression models, with other covariates (grade, family affluence, and other PHL domains) held constant. Shaded areas represent 95% confidence intervals.

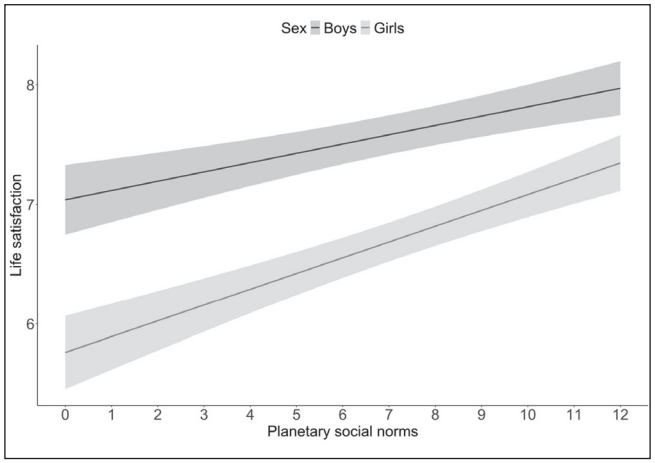

Fig. 2. *Predicted life satisfaction (Cantril's ladder) by perceived planetary social norms and sex (model 3).*

Lines represent adjusted predicted values across the observed range of perceived social norms; shaded areas indicate 95% confidence intervals. Predictions are based on the fully adjusted regression models, with other covariates (grade, family affluence, and other PHL domains) held constant. Shaded areas represent 95% confidence intervals.

Associations between Health-related Behaviours and Planetary-health Literacy

To examine whether planetary-health literacy relates to day-to-day habits, we computed Spearman rank correlations between PHL scores and selected behaviours (Table 3). Fruit and vegetable intake were strongly correlated ($\rho = 0.69$, $p<0.001$), as were cigarette smoking and e-cigarette use ($\rho = 0.68$, $p < 0.001$). The PHL overall score showed small, positive correlations with fruit and vegetable consumption (both $\rho = 0.15$, $p<0.001$) and small, inverse correlations with cigarette smoking ($\rho = -0.09$, $p<0.001$) and e-cigarette use ($\rho = -0.10$, $p<0.001$). Patterns by subscale were consistent: Knowledge correlated positively with fruit/vegetables (both $\rho = 0.11$) and negatively with smoking and e-cigarettes ($\rho = -0.09$ to -0.10, all $p<0.001$). Action related to diet only (fruit $\rho = 0.15$, vegetables $\rho = 0.14$, both $p<0.001$) and was not associated with nicotine use ($\rho \approx 0$). Perceived pro-environmental social norms correlated positively with fruit and vegetables intake ($\rho = 0.12$ and 0.11) and inversely with both nicotine behaviours ($\rho = -0.11$ each, all $p < 0.001$).

DISCUSSION

This study is, to our knowledge, the first to look at the relation between planetary-health literacy and multiple indicators of mental health in Central European adolescents. Using nationally representative cross-sectional data, association between perceived pro-environmental social norms and higher wellbeing and life

Table 3. *Spearman correlation coefficients between planetary health subscales and selected environment-related behaviours*

Variable		1	2	3	4	5	6	7
1	Fruit consumption							
2	Vegetable consumption	0.69***						
3	Tobacco smoking	−0.09***	−0.05***					
4	E-cigarettes	−0.08***	−0.05***	0.68***				
5	PHL knowledge	0.11***	0.11***	−0.09***	−0.10***			
6	PHL action	0.15***	0.14***	0.00	−0.01	0.41***		
7	PHL social norms	0.12***	0.11***	−0.11***	−0.11***	0.51***	0.46***	
8	PHL overall score	0.15***	0.15***	−0.09***	−0.10***	0.87***	0.74***	0.77***

PHL – planetary-health literacy; ***p < 0.001

satisfaction was shown. Second, greater action was linked to better wellbeing but not to life satisfaction or psychological complaints. Third, higher knowledge scores were weakly associated with poorer wellbeing and more psychological symptoms.

Our results support the evidence that socially endorsed engagement is psychologically beneficial for youth. Existing work suggests that adolescents' pro-environmental behaviour and emotional health is shaped not only by their attitudes, but also by norms within their social networks (20). Similarly, a recent Italian study found that in a sample of slightly older adolescents pro-environmental actions were associated with higher personal and social wellbeing (21). In line with these findings, our results indicate that perceiving one's close environment as environmentally responsible is associated with measurable mental-health advantages – even after adjusting for family affluence and sex.

The small but significant negative association between environmental knowledge and wellbeing is in line with the existing knowledge on the concept of eco-anxiety, the distress linked to awareness of ongoing environmental change. In the largest survey to date, 84% of surveyed adolescents were at least moderately worried about climate change, while 59% of 10,000 youth in ten countries reported being "very or extremely worried" about climate change, and 45% said that their feelings affected their daily life function (4). More recently, a longitudinal study across eleven European countries found that climate-change worry was associated with future reported anxiety symptoms. Moreover, the strength of association was different among participating countries highlighting the need for country specific data and tailored approaches (22). Despite limitations of cross-sectional design, our current findings also illustrate that public health and climate-education programmes should target not only knowledge but also provide meaningful opportunities for engagement as focus only to knowledge building could potentially increase the experienced climate-related distress.

Recent work has proposed conceptualizing health-related behaviours explicitly in a climate-change perspective, based on the bidirectional links and potential co-benefits. This framing is followed by our exploratory analysis, which aims to base the PHL within a broader behavioural context, without claiming direct behavioural effects (23). The additional analyses linking PHL to diet and nicotine use suggest that the connection between healthy and sustainable behaviours could exist also among Czech adolescents. The small but consistent positive associations between higher fruit and vegetable intake and all three PHL domains are in line with existing evidence that young people who hold stronger pro-environmental attitudes are more compliant with plant-based eating patterns. Conversely, the inverse relationships observed for e-cigarette use are consistent with research showing that adolescents who are aware of the environmental harms of tobacco waste are less supportive of smoking and more receptive to restrictive policies (24). Taken together, these findings also illustrate the existence of co-benefits between planetary and human health: strengthening planetary-health literacy may simultaneously support a shift towards more environmentally friendly and healthier lifestyle choices which then translates into positive population health outcomes (25). However, PHL is only one of many levers shaping everyday decisions (26), which is also visible from the low strength of recorded associations; future work should test whether integrated school programmes that couple sustainability education with specific behaviour-change interventions help to gain these dual benefits.

There was a visible sex difference in the reported PHL scores and observed small sex x social-norms interactions, as reported in Figures 1–3. Girls scored higher on all three PHL dimensions yet reported lower wellbeing and more psychological complaints. Socioeconomic gradients in PHL were modest, but even small knowledge and norms gaps across affluence groups could theoretically widen mental-health disparities on a population scale, if left unaddressed. However, it should be noted that all associations and interaction effects were only modest and should be interpreted cautiously, especcially given the cross-sectional design.

Nonetheless, the findings still support planetary-health education programmes to move beyond simple knowledge transfer, to also consider other dimensions of environmental health literacy, including opportunities for action. School-based interventions that are built on collective action projects (e.g., student-led sustainability campaigns) and explicitly cultivate supportive peer norms may teach the students about planetary-health topics while taking care about adolescent mental-health needs. These strategies align with public health calls to integrate ecological and human-health goals in educational policy (27).

Access to the large, nationally representative HBSC sample together with the usage of validated multidimensional PHL scales, and the concurrent assessment of key mental-health and behavioural outcomes are among the core strengths of the presented study. However, several limitations must be considered. First, the cross-sectional design cannot provide information on the directionality of the relationship between PHL and measured outcomes and generally limits any conclusions related to causality. Second, the reliance on self-reported data may introduce misinformation bias. This is also further limited by the absence of detailed and objective indicators of environmental knowledge or behaviour. Moreover, longitudinal follow-up is missing. Behavioural correlates were exploratory and based on limited HBSC items. Fruit and vegetable intake does not capture animal-source food consumption and information on total diet quality or intake of ultra-processed foods is missing. Hence, the observed associations cannot be interpreted as links between planetary-health literacy and a fully "sustainable diet." Moreover, all variables, including tobacco and e-cigarette use, were self-reported. Socially desirable responding may have led some students to overstate healthy behaviours and under-report unhealthy ones, potentially attenuating true effect sizes. These limitations could also explain why the reported associations, while statistically significant, were only modest, in line with the multifactorial nature of adolescent mental health.

CONCLUSIONS

Among Czech adolescents, feeling surrounded by pro-environmental social norms is linked to better mental health, whereas environmental knowledge was associated with lower wellbeing. Moreover, higher PHL scores were weakly associated with healthier habits. Interventions that combine climate education with opportunities for environmental action and social support, for example in the form of student-led cooperative projects (e.g., student-led audits of food waste) could therefore bring dual benefits for planetary and adolescent psychological health. Future research should test these associations across diverse cul-

tural settings and focus on evaluation of integrated school-based programmes designed within this planetary-health framework.

Conflicts of Interest

None declared

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