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The Implications of the COVID-19 Pandemic for the Construction of the Family Affluence Scale: Findings from 16 Countries

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Abstract

The Family Affluence Scale (FAS) is a widely used and validated instrument to measure adolescents' socioeconomic status (SES). It is plausible that the COVID-19 pandemic and resulting social and economic changes have affected the capacity of the six-item FAS-III to measure adolescent SES, particularly the holiday and computer items. Using data from 247,503 adolescents from 16 European countries participating in the Health Behaviour in School-aged Children (HBSC) study before (2013/14 and 2017/18) and during (2021/22) the pandemic, the present study aims to fill this gap. Findings showed that although the internal consistency of the scale decreased during the pandemic, related to the functioning of the computer and especially the holiday item, it was still acceptable in all countries. Furthermore, measurement invariance analysis showed that during the pandemic the item thresholds of the computer and particularly the holiday item deviated from the thresholds of these items before the pandemic. However, all item factor loadings were comparable to the factor loadings before the pandemic. In addition, during the pandemic the computer and holiday item and their correlations with health-related outcomes were mostly still in the expected direction. Removing these items from the scale yielded comparable or decreased scale criterion validity as compared to the original FAS-III scale in most countries. These findings inform future research that although mean differences in family affluence levels before and during the pandemic should be interpreted with caution, it is a suitable tool to study (changes in) socioeconomic health inequalities among adolescents during the pandemic.

Keywords Family Affluence Scale · Socioeconomic status · Validation study · Adolescents · COVID-19 · Health Behaviour in School-aged Children

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1 Introduction

On 11 March 2020, the World Health Organization (WHO) declared the spread of COVID-19 – the disease caused by the SARS-CoV-2 virus – a pandemic. Following this, governments implemented a range of measures to limit the transmission of the virus, such as lockdowns, quarantines, school closures, and travel restrictions. These infection prevention and control (IPC) measures changed the lives of all, and particularly affected adolescents given their critical developmental stage (Garagiola et al., 2022). The COVID-19 pandemic has been labelled *syndemic*, meaning that it has exacerbated pre-existing socioeconomic health inequalities (Bambra et al., 2020).

The international Health Behaviour in School-aged Children (HBSC) study, conducted among 11-, 13- and 15-year-olds in a growing number of countries in Europe and in North America since 1982 (Inchley et al., 2020), provides a unique opportunity to investigate this phenomenon among young people. HBSC includes nationally representative data on health and health behaviours from adolescents with different socioeconomic backgrounds before and during the pandemic. The HBSC study uses the Family Affluence Scale (FAS) to assign adolescents' socioeconomic status (SES) based on material assets within the family (Inchley et al., 2020). Furthermore, in past decades ample studies outside HBSC have used the FAS to measure adolescents' SES (e.g., López-Gil et al., 2021; Shankar-Krishnan et al., 2018). This study examined whether the COVID-19 pandemic and resulting social and economic changes have altered the capacity of the FAS to measure adolescent SES by comparing data collected before and during the pandemic across 16 countries participating in the HBSC study. As such, this study aims to facilitate future research on socioeconomic health inequalities, particularly in light of the pandemic.

1.1 Properties of the FAS

The FAS was designed to capture adolescents' material affluence based on indicators of material possessions within the family household (Currie et al., 2008). The measure distinguishes itself from other instruments that measure SES among adolescents, because it is based on questions adolescents know the answer to, unlike questions about their parents' occupation or education, where they may have limited knowledge about (Currie et al., 2008; Lien et al., 2001). Its component items have changed over the years in line with changing social and economic conditions of families in Europe and North America (Currie et al., 1997, 2008). The third and current version of the FAS, known as FAS-III, includes six items: number of *cars* in the family, having a private *bedroom*, number of *computers*, number of *bathrooms*, having a *dishwasher*, and number of family *holidays* abroad in past year (Torsheim et al., 2016). The six-item FAS-III has been extensively used in surveys since 2013/14, featuring in single-country and internationally-comparative scientific HBSC publications (Belardinelli et al., 2022; Bosakova et al., 2020; Chatelan et al., 2021; Chzhen et al.,

2018; Hammami et al., 2022; Sigmundová et al., 2019; Weinberg et al., 2019), as well as international HBSC reports (Inchley et al., 2016, 2020). The FAS-III also has been assessed among adolescents and adults in other studies outside HBSC in countries such as Brazil, Spain, the Netherlands, Germany, and the United States (López-Gil et al., 2021; Shankar-Krishnan et al., 2018; Stevens et al., 2022; Wachs et al., 2019; Walker et al., 2021).

The reliability of the current and earlier versions of the FAS has been well established and most recent studies have shown a high test-retest reliability and strong consistency between child and parental reports on the FAS-III items (Torsheim et al., 2016). Furthermore, validity has been extensively proven. For example, moderate correlations between FAS-III scores and parental reported education and occupation were found (Corell et al., 2021; Torsheim et al., 2016). Strong correlations between regional FAS-III scores and local income per capita confirmed appropriate external criterion validity (Hobza et al., 2017). Despite demonstrated validity and reliability, research shows that the factor structure of the FAS-III was partially invariant across eight countries, which could limit the ability to compare mean levels of family affluence across countries (Torsheim et al., 2016). To account for this, transforming absolute sum-scores into 'ridit' scores is recommended in international research (Schnohr et al., 2008). Ridit scores represent cumulative proportional ranks that indicate adolescents' family affluence relative to their country of residence (Elgar et al., 2013, 2017).

1.2 The Influence of the Pandemic on the Measurement Properties of FAS

The COVID-19 pandemic and the IPC measures implemented by governments to control its spread may have affected the capacity of some of the FAS items to adequately differentiate between socioeconomic groups. Particularly, before and during the 2021/22 survey assessment, travelling abroad was restricted. In many countries, adolescents' reported *number of holidays* abroad in past year might thus be less reflective of their SES than in earlier years. In addition, schools were closed for varying lengths of time and online teaching was implemented in almost all countries around the world. To support adolescents, some countries, regions, and schools developed policies to provide computers or pay for internet access to help students learn remotely (UNICEF, 2020). In such cases, the *number of computers* within the household may be a less appropriate indicator of SES than in previous survey years.

Given this context, the correlation between the holiday and computer items with other FAS-items may be weaker during the pandemic, leading to decreased internal consistency of the scale. Furthermore, the contribution of the holiday and computer item to the underlying factor structure of the FAS may have changed in the pandemic, which could complicate comparisons in family affluence over time. Additionally, the holiday and computer items may correlate less strongly to constructs they are theoretically related to during the pandemic than in earlier years, which may result in decreased criterion validity.

1.3 Current Study

Using data from 247,503 adolescents from 16 countries participating in the HBSC study, the present study examined (1) changes in the internal consistency, (2) measurement invariance, and (3) changes in the criterion validity of the FAS during the COVID-19 pandemic. More specifically, we examined changes in the internal consistency and criterion validity of the FAS between 2017/18 and 2021/22 (i.e., before and during the pandemic), and compared this with changes in these measurement properties between 2013/14 and 2017/18 (i.e., both before the pandemic). We also tested whether the factor structure of the FAS was measurement invariant across 2013/14, 2017/18, and 2021/22. We expected that, in 2021/22, the internal consistency of the items has weakened (Hypothesis 1), the scale was not measurement invariant (Hypothesis 2), and the criterion validity has decreased (Hypothesis 3), due to poorer item functioning of the holiday and computer item during the pandemic.

2 Methods

2.1 Data

Data were used from countries that participated in the 2013/14, 2017/18, and 2021/22 HBSC survey waves. Although more than 50 countries participated in the HBSC study, the current study used an early version of the data that was released by October 2022, which covered 16 countries. This selection yielded a sample of 247,503 adolescents ($n_{2013/14}$ = 77,170; $n_{2017/18}$ = 79,285; $n_{2021/22}$ = 91,048, M_{age} = 13.56, SD_{age} = 1.64). These data were cross-sectional, that is, different adolescents were sampled each survey round. Respondents were sampled via schools. Data collection followed a strict protocol ensuring data quality and ethical safeguarding of the respondents (Inchley et al., 2023). After a translation and back-translation procedure following the protocol, questionnaires were administered in the language of the respective country. Participants provided active consent, and depending on the country, parents or legal guardians provided active or passive consent. In each country, the study procedures were approved by institutional ethics committees. In each wave, countries carried out their fieldwork within one or several month(s). Sample sizes for each country by survey year and month can be found in the Supplement (Table S1a-c).

2.2 Measure

The six-item FAS-III scale uses the following items: (1) 'Does your family own a car, van, or truck?' (0 *no*, 1 *yes, one*, and 2 *yes, two or more*), (2) 'Do you have your own bedroom for yourself?' (0 *no* and 1 *yes*), (3) 'How many computers does your family own (including laptops and tablets, not including game consoles and

smartphones)?' (0 *none*, 1 *one*, 2 *two*, and 3 *more than two*), (4) 'How many bathrooms (room with a bath/shower or both) are in your home?' (0 *none*, 1 *one*, 2 *two*, and 3 *more than two*), (5) 'Does your family have a dishwasher at home?' (0 *no* and 1 *yes*), and (6) 'How many times did you and your family travel out of [country] for a holiday/vacation last year'? (0 *never*, 1 *once*, 2 *twice*, and 3 *more than twice*) (Torsheim et al., 2016).

2.3 Analyses

2.3.1 FAS-Holidays and -Computers Items Over Time

We examined whether the percentages of adolescents (1) not going on holiday abroad at all and (2) with more than two computers were higher in 2021/22 than in 2017/18 using Chi-square tests. For reference, we also examined whether these percentages changed between 2013/14 and 2017/18. We further studied the percentage of adolescents not going on holiday and with more than two computers by month of survey participation. These percentages may vary by month, because for example the implementation of travel bans varied *within* the year of fieldwork, depending on IPC measures in place at specific times.

2.3.2 Internal Consistency

For our first hypothesis, we investigated the internal consistency of the six FAS items for each country in 2013/14, 2017/18, and 2021/22. We treated the six FAS-items as ordered categorical variables (Torsheim et al., 2016). Correspondingly, internal consistency was calculated based on the polychoric correlation matrix, referred to as the ordinal alpha (Gadermann et al., 2012). Values higher than 0.60 indicate acceptable internal consistency (Robertson & Evans, 2020; Taber, 2018). For each country, we investigated whether ordinal alpha was lower in 2021/22 than in 2017/18, and for reference we also compared this for 2013/14 and 2017/18. To find the source of decreased alpha, we inspected changes in correlations between the six items over time. These correlation differences were analyzed using z-scores.

2.3.3 Measurement Invariance

To test our second hypothesis, measurement invariance was investigated using multiple group analysis. For each country separately, we fitted a one-factor model with all six ordered categorical items, where factor loadings and thresholds were freely estimated across 2013/14, 2017/18, and 2021/22, referring to *configural invariance*. Model fit was evaluated based on the Comparative Fit Index (CFI ≥ 0.9 = acceptable; ≥ 0.95 = excellent), Tucker Lewis Index (TLI; ≥ 0.9 = acceptable; ≥ 0.95 = excellent), and Root Mean Square Error of Approximation (RMSEA; < 0.08 = acceptable; < 0.05 = excellent) (Van de Schoot et al., 2012). Next, we constrained the factor loadings to be equal across the three waves, referring to *metric invariance*. Subsequently, we constrained the item thresholds to be equal across the three waves,

indicating *scalar invariance*. In case metric and/or scalar invariance did not hold, we inspected modification indices to find the items that caused misfit (Dimitrov, 2010). We removed the model constraints one item at the time, starting with the item that caused the most misfit, to achieve *partial invariance*. Metric (partial) invariance was established when the model fit was not substantially worse than the configural model, and scalar (partial) invariance was achieved when it did not fit substantially worse than the metric (partial) model (ΔCFI $\geq$ -0.010 and ΔRMSEA $\leq$ 0.015) (Chen, 2007; Cheung & Rensvold, 2002). We did not rely on changes in Chi-square to evaluate model fit because of its sensitivity to large sample sizes (Chen, 2007; Cheung & Rensvold, 2002).

2.3.4 Criterion Validity

Regarding the third hypothesis, we examined criterion validity, which investigates whether measures relate to constructs they should theoretically be related to. To do so, we studied correlations between the FAS-items and constructs that have been demonstrated to be associated with family affluence, including parent employment (Corell et al., 2021), mental health (Dierckens et al., 2020; Weinberg et al., 2021), family communication (Ramdahl et al., 2018), food intake (Chatelan et al., 2021; Fismen et al., 2012), and physical activity (Falese et al., 2021). Specifically, we analyzed correlations between family affluence items and mother employment, father employment, life satisfaction, psychosomatic complaints, talking to father, talking to mother, fruit consumption, vegetable consumption, and the levels of vigorous and moderate-to-vigorous physical activity. Details of these measures can be found in the Supplement (Table S2). For each country, we investigated whether these correlations changed in 2021/22 compared to 2017/18, whereby we expected weaker correlations with the holiday and computer items in 2021/22 as compared to 2017/18. For reference, we also compared correlations in 2013/14 and 2017/18. Again, we used *z*-scores to study these correlation differences.

As a final step, we examined whether the correlation between family affluence and the selected indicators was stronger when employing revised FAS-III scales (i.e., without holiday and/or computer item) as compared to the original FAS-III scale (i.e., all six items) in 2021/22. In doing so, we used adolescents' relative family affluence (ridit) given their residential country, age, and sex (Elgar et al., 2017).

2.3.5 Missing Data

In the pooled sample, missing data on the FAS ranged between 1.72% (car in 2021/22) and 5.24% (holidays in 2013/14), although this rate varied substantially across countries (max. 24.89% dishwasher in Slovakia 2017/18). Missing on the other variables ranged between 0.96% (fruit consumption in 2013/14) and 15.73% (talk to father in 2021/22). Few countries presented high missing rates for specific questions that were not examined or only examined among specific age groups (100% talk to mother/father in Slovakia 2021/22, 69.40/68.93% employment father/mother in Austria 2013/14, and 39.64/37.20% employment father/mother in the Netherlands 2013/14). For the

remainder, missing rates on the other variables varied across countries (max. 34.15% talk to father in Slovakia 2017/18), but were not or only to a small extent associated with sex, age, and all study variables ($r_{average} = 0.02$). The present analyses handled missing data using pairwise deletion.

2.3.6 Technical Details

Analyses were conducted using Mplus 8.8 (Muthén & Muthén, 2017) and R 4.4.2 (Hallquist & Wiley, 2018; R Core Team, 2022). All analyses corrected standard errors for clustering of adolescents within schools or classes. Hence, cases with missing cluster identifier were excluded from the analyses ($n = 70$). As appropriate for (ordered) categorical outcome variables, correlation analyses and measurement invariance were analyzed using Weighted Least Square Means and Variance Adjusted (WLSMV) estimation (Rhemtulla et al., 2012). In all analyses, significance was assumed with $p < 0.05$. Scripts for all analyses can be consulted at https://osf.io/rvqew/.

3 Results

3.1 FAS-Holidays and -Computers Item Over Time

In 15 out of 16 countries, the percentage of adolescents not going on holiday abroad at all increased between 2017/18 and 2021/22 (Table 1A). In most (nine) of these countries, this percentage did not significantly change between 2013/14 and 2017/18. The percentage of adolescents with more than two computers increased in 10 out of 16 countries between 2017/18 and 2021/22 (Table 1B). However, in most (eight) of these countries, this increase was not specific of 2021/22, because it also increased between 2013/14 and 2017/18. Thus, between 2017/18 and 2021/22 changes in the distribution of the holiday item were more pronounced than changes in the distribution of the computer item. Details regarding the distribution in adolescents' number of holidays abroad and computers within the household can be consulted in the Supplement (Table S3a-b).

Figure 1A shows the proportion of adolescents not going on holiday by month of survey participation. In 2021/22, these proportions varied across months, but followed a similar pattern as observed in 2017/18, although 2017/18 had systematically lower proportions of adolescents not going on holiday. Figure 1B shows that generally, the proportion of adolescents with more than two computers in the household decreased between September '21 and August '22. However, a decrease was also observed between September '17 and August '18. Thus, the observed monthly variance in the holiday and computer item in 2021/22 was comparable to 2017/18.

3.2 Internal Consistency

In 2021/22, ordinal alpha ranged between 0.608 (Croatia) and 0.721 (Albania), indicating acceptable internal consistency between the items (Table 2). In 11 out of 16

Table 1 Scores on the holiday and computers items, by country and year

(A) % not going on family holiday abroad at all					(B) % with more than two computers in the household				
	n	2013/14	2017/18 (ref.)	2021/22		*n*	2013/14	2017/18 (ref.)	2021/22
Sweden	15,804	26.06	24.59	56.74***	Austria	12,501	51.59***	63.09	75.25***
England	12,210	25.03	24.66	53.60***	Croatia	15,793	35.35***	42.60	53.29***
Denmark	11,660	18.92	17.61	30.67***	Luxembourg	11,296	60.02***	66.82	76.25***
Slovenia	16,584	10.86	9.64	15.76***	Belgium (Flemish)	17,856	66.17***	76.07	83.07***
Austria	12,434	13.46	13.62	20.04***	Slovakia	13,982	43.63*	46.80	54.96***
Macedonia	12,796	22.78	24.06	29.56***	Slovenia	16,610	52.3***	60.49	67.1***
Croatia	15,678	42.06	39.88	44.97***	Hungary	11,681	35.48***	50.37	56.82**
Luxembourg	11,267	5.96	5.90	8.27***	Netherlands	15,842	79.91***	84.96	82.63*
Belgium (Flemish)	17,844	16.56	14.73	17.73***					
					Albania	12,137	5.55***	17.11	16.52
Estonia	13,544	35.43***	26.65	45.89***	Denmark	11,626	79.23***	84.72	85.93
Netherlands	12,730	19.06**	15.72	31.75***	Estonia	13,576	53.75***	69.61	71.40
Slovakia	13,932	25.50**	21.96	37.83***	Macedonia	12,831	18.83***	35.91	38.71
Albania	12,134	47.14***	40.69	49.90***	England	12,235	71.39***	76.66	78.70
Czech Republic	29,339	7.73***	22.94	34.13***	Czech Republic	29,248	52.72	54.55	66.75***
France	19,763	27.75**	30.76	37.66***					
					France	19,774	62.44**	59.21	62.4**
Hungary	11,661	54.27***	45.74	48.2					
					Sweden	15,842	79.91***	84.96	82.63*

Countries were grouped by changes between 2013/14, 2017/18, and 2021/22

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$ based on chi-square tests with 2017/18 as the reference group (ref.)

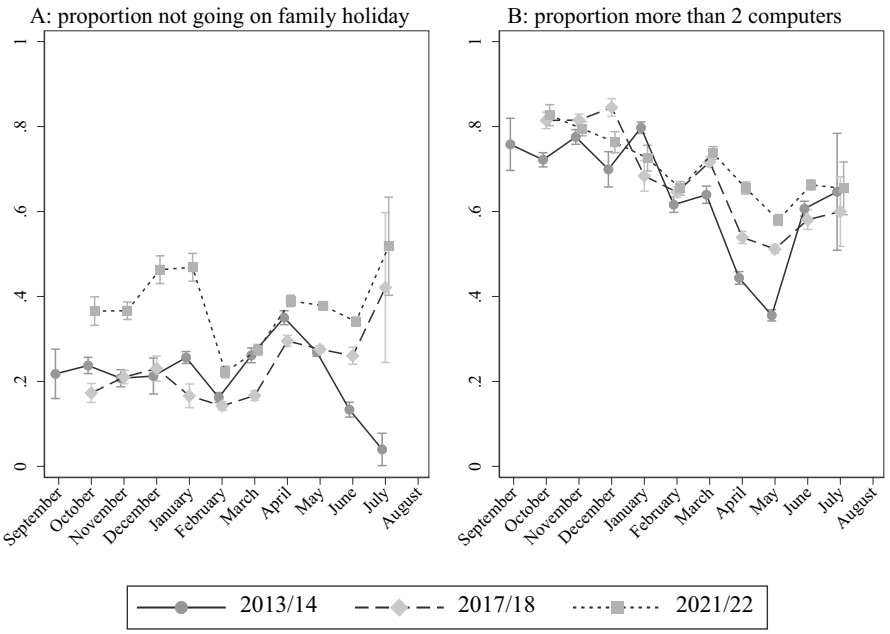

Fig. 1 Scores on the holiday and computer items, by year

countries, ordinal alpha decreased in 2021/22 relative to 2017/18. In eight of these 11 countries, the holiday item was (one of) the main source(s) of this decrement, because it showed the highest number of decreased correlations with other FAS-items. The computer item was (one of) the main source(s) of decreased alpha in four countries. The other FAS-items did not or less often account for decreases in ordinal alpha. In 2017/18, the ordinal alpha decreased in 10 out of 16 countries relative to 2013/14. In five of these 10 countries, the holiday and/or computer item were (one of) the main source(s) of this decrement; in three countries this was true for the car item. In respectively one country, the bedroom, bathroom, and dishwasher items were one of the main sources of the drop in ordinal alpha.

Thus, the holiday and computer item contributed more strongly to a decreased internal consistency in 2021/22 than other FAS-items, in line with Hypothesis 1. However, this does not seem to be specific to 2021/22 because this was also the case in 2017/18, although to a lesser extent. Correlation matrices of all items by country and year can be found in the Supplement (Table S4a-p).

3.3 Measurement Invariance

Table 3 shows that in all countries, the configural model showed acceptable to excellent model fit for a one-factor model in the three survey waves. Metric invariance was established in all countries, because constraining the factor loadings to be equal across time did not substantially deteriorate model fit, and even improved model

Table 2 Internal consistency FAS-items, by country and year

	Ordinal alpha			Δ ordinal alpha	Number of correlations between item and other FAS-items that decreased in 2021/22 relative to 2017/18						Δ ordinal alpha	Number of correlations between item and other FAS-items that decreased in 2017/18 relative to 2013/14					
	2013/14	2017/18	2021/22	Δ2021/22	Holiday	Comput-ers	Car	Bedroom	Bath-room	Dish-washer	Δ2017/18	Holiday	Comput-ers	Car	Bedroom	Bath-room	Dishwasher
Albania	0.774	0.801	0.721	-0.080	3	3	**5**	3	**5**	3	0.027	0	**1**	**1**	0	0	0
Austria	0.677	0.674	0.712	0.038	0	0	0	0	0	0	-0.003	0	**2**	0	0	1	1
Belgium (Flemish)	0.664	0.692	0.696	0.004	0	0	0	0	0	0	0.028	1	1	0	0	**2**	0
Croatia	0.665	0.649	0.608	-0.041	1	**3**	0	1	1	2	-0.016	0	0	**1**	0	0	**1**
Czech Republic	0.678	0.697	0.687	-0.010	**2**	0	1	0	1	0	0.019	0	**2**	1	0	0	1
Denmark	0.750	0.720	0.709	-0.011	0	0	0	0	0	0	-0.030	**2**	1	1	0	0	0
England	0.731	0.739	0.694	-0.045	**5**	2	3	1	2	1	0.008	0	0	0	0	0	0
Estonia	0.719	0.711	0.655	-0.056	**5**	1	1	1	1	1	-0.008	**1**	0	**1**	0	0	0
France	0.687	0.660	0.677	0.017	0	0	0	0	0	0	-0.027	**2**	**2**	0	0	1	1
Hungary	0.727	0.752	0.693	-0.059	**3**	**3**	**3**	2	**3**	0	0.025	0	0	0	0	0	0
Luxembourg	0.753	0.726	0.712	-0.014	**1**	**1**	0	0	0	0	-0.027	0	**1**	0	**1**	**1**	**1**
Macedonia	0.749	0.690	0.687	-0.003	**2**	1	**2**	0	0	1	-0.059	1	**5**	1	2	2	3
Netherlands	0.697	0.688	0.622	-0.066	**3**	**3**	2	1	2	1	-0.009	0	0	0	0	**1**	**1**
Slovakia	0.704	0.655	0.673	0.018	0	0	0	0	0	0	-0.049	**3**	**3**	**3**	0	2	1
Slovenia	0.686	0.664	0.683	0.019	0	0	0	0	0	0	-0.022	**4**	1	1	0	1	1
Sweden	0.708	0.735	0.702	-0.033	**5**	2	3	1	1	2	0.027	0	0	0	0	0	0

Highlighted cells denote countries with decrease in ordinal alpha relative to previous measurement; Boldface numbers denote the year-specific row maximum; Countries also showed some increased correlations between the FAS-items, which are not shown in the table

FAS Family Affluence Scale

Table 3 Results measurement invariance analysis, by country

	Configural (57[a])						Metric (47[a])		Scalar (23[a])		Partial scalar[b]		
	n	Chi-square[c]	CFI	TLI	RMSEA	SRMR	CFI	RMSEA	CFI	RMSEA	CFI	RMSEA	Adjustments to item thresholds[d]
Albania	12,179	395.850	0.965	0.942	0.058	0.036	0.964	0.050	0.916	0.060	0.956	0.046	computers 2013/14, car 2021/22, dishwasher 2013/14
Austria	12,570	156.594	0.969	0.949	0.034	0.029	0.969	0.029	0.876	0.045	0.965	0.026	computers 2013/14, **holiday 2021/22**, **computers 2021/22**
Belgium (Flemish)	17,944	187.930	0.975	0.959	0.032	0.023	0.969	0.030	0.925	0.037	0.960	0.030	**computers 2021/22**, **holiday 2021/22**, bathroom 2017/18, holiday 2017/18
Croatia	15,967	176.270	0.976	0.960	0.032	0.023	0.977	0.027	0.928	0.037	0.967	0.027	**holiday 2021/22**, bathroom 2013/14, **computers 2021/22**
Czech Republic	29,430	517.882	0.970	0.950	0.043	0.027	0.973	0.035	0.846	0.065	0.963	0.034	**holiday 2021/22**, holiday 2013/14, **computers 2021/22**
Denmark	11,714	79.086	0.989	0.981	0.022	0.024	0.989	0.019	0.916	0.040	0.982	0.020	**holiday 2021/22**, computers 2013/14
England	12,319	154.466	0.983	0.972	0.034	0.025	0.976	0.035	0.870	0.063	0.968	0.033	**holiday 2021/22**, computers 2013/14
Estonia	13,635	210.882	0.974	0.956	0.039	0.028	0.968	0.036	0.892	0.052	0.958	0.034	**holiday 2021/22**, computers 2013/14, dishwasher 2021/22
France	20,004	244.058	0.972	0.953	0.035	0.025	0.976	0.027	0.943	0.033	0.970	0.026	holiday 2013/14, **holiday 2021/22**, computers 2013/14,
Hungary	11,711	239.179	0.964	0.940	0.045	0.030	0.960	0.041	0.928	0.042	0.951	0.038	car 2021/22, computers 2013/14, dishwasher 2021/22, **holiday 2021/22**
Luxembourg	11,415	143.755	0.980	0.967	0.034	0.027	0.982	0.027	0.933	0.041	0.974	0.028	**holiday 2021/22**, **computers 2021/22**, bathroom 2013/14,

Table 3 (continued)

	Configural (57[a])						Metric (47[a])		Scalar (23[a])		Partial scalar[b]		
	n	Chi-square[c]	CFI	TLI	RMSEA	SRMR	CFI	RMSEA	CFI	RMSEA	CFI	RMSEA	Adjustments to item thresholds[d]
Macedonia	12,868	408.764	0.955	0.925	0.057	0.034	0.964	0.044	0.908	0.054	0.954	0.042	computers 2013/14, **holiday 2021/22**, **computers 2021/22**, bedroom 2013/14
Netherlands	12,784	151.832	0.967	0.945	0.033	0.030	0.970	0.027	0.838	0.049	0.963	0.026	**holiday 2021/22**, **computers 2021/22**, bathroom 2021/22, computers 2013/14
Slovakia	14,204	369.639	0.954	0.924	0.052	0.032	0.958	0.042	0.854	0.062	0.949	0.040	**holiday 2021/22**, dishwasher 2013/14, computers 2013/14, car 2013/14
Slovenia	16,687	205.905	0.977	0.961	0.035	0.024	0.971	0.033	0.928	0.040	0.961	0.032	**holiday 2021/22**, **computers 2021/22**, holiday 2017/18
Sweden	15,946	186.862	0.978	0.963	0.033	0.027	0.974	0.031	0.852	0.057	0.967	0.029	**holiday 2021/22**, computers 2013/14, car 2013/14

n = sample size; *CFI* Comparative Fit Index; *TLI* Tucker-Lewis Index; *RMSEA* Root Mean Square Error of Approximation; *SRMR* Standardized Root Mean Square Residual

[a] Number of free parameters

[b] Number of free parameters varied across countries, depending on the number of thresholds that were allowed to vary

[c] With 27 degrees of freedom

[d] Items are ordered based on their contribution to model fit improvement after releasing the respective thresholds. Boldface items highlight the items that were expected to be non-invariant

fit in seven countries. The scalar model substantially deteriorated model fit in all countries, indicating that item thresholds varied across time. Partial scalar invariance was obtained in all countries by releasing equality constraints of the thresholds. More specifically, modification indices showed that in 15 out of 16 countries, the thresholds of the holiday 2021/22 item were different than in 2013/14 and 2017/18. In 10 of these 15 countries, these differences were the main source of non-invariance, because releasing constraints on these thresholds yielded the largest model fit improvement. The thresholds of the computer 2021/22 item varied in eight out of 16 countries, but only in one country it was the main source of non-invariance. Thresholds of the holiday and computer items in earlier years, as well as other FAS-items, did not vary in more than two countries, except for the thresholds of the computer item in 2013/14: these varied in 11 out of 16 countries, while being the main source of non-invariance in three countries. Factor loadings of all items by country according to the final partial scalar models can be found in the Supplement (Table S5).

Thus, in many countries, the thresholds of both the holiday 2021/22 and computer 2021/22 item varied over time and varied more often and/or stronger than other items (except for the thresholds of the computer 2013/14 item), which corresponds with Hypothesis 2. In general, the thresholds of the holiday item were higher in 2021/22 than in earlier years. This means that higher scores on the holiday item in 2021/22 reflect higher levels of family affluence than in previous surveys. Non-invariance of the 2021/22 computer item was because thresholds were lower in 2021/22 than in earlier years, indicating that higher scores on the computer item in 2021/22 reflect lower levels of family affluence than in previous surveys.

3.4 Criterion Validity

In general, (very) small to moderate associations were found between the FAS-items and the 10 outcomes related to parent employment, mental health, physical activity, food intake, and social support, although these correlations differed substantially across countries (see Supplement Table S6a-p). Table 4 summarizes changes in these correlations over time by country. In 12 out of 16 countries, correlations between the holiday item and one to five outcomes were weaker in 2021/22 than in 2017/18. In none of the countries, correlations between the holiday item and the included outcomes were stronger in 2021/22 than in 2017/18. With respect to the computer item, the correlation with one outcome became weaker in only one country in 2021/22. In contrast, in 13 out of 16 countries, correlations between the computer item and one or more outcomes were stronger in 2021/22 compared to 2017/18. The other FAS-items were less negatively affected in 2021/22: their correlations with the outcomes became weaker in three to six countries, but with no more than two outcomes. Between 2013/14 and 2017/18, negative changes in correlations between the FAS-items and the outcomes were more balanced across the FAS-items than between 2017/18 and 2021/22 (i.e., not particularly related to the holiday item as in 2021/22).

Table 5 shows the correlations between family affluence and the selected outcomes using different operationalizations of the FAS-III scale in 2021/22. In 11

Table 4 Summary item criterion validity, by country and time

	Number of correlations between item and selected outcomes that *decreased* in 2021/22 relative to 2017/18						Number of correlations between item and selected outcomes that *decreased* in 2017/18 relative to 2013/14					
	Holiday	Computer	Car	Bedroom	Bathroom	Dishwasher	Holiday	Computer	Car	Bedroom	Bathroom	Dishwasher
Albania	2	0	0	0	1	1	0	3	1	0	0	0
Austria	0	0	0	0	0	0	0	0	0	0	0	0
Belgium (Flemish)	1	0	0	0	0	0	0	0	1	0	1	0
Croatia	0	0	0	1	0	1	1	0	0	1	2	0
Czech Republic	4	0	0	0	1	0	0	1	0	0	0	0
Denmark	2	0	1	0	1	0	1	0	0	1	0	1
England	2	0	1	0	2	0	0	0	1	1	1	0
Estonia	3	0	0	1	1	1	0	0	0	1	1	0
France	0	0	0	0	0	0	0	0	0	0	0	0
Hungary	0	0	1	0	0	0	1	3	2	1	0	0
Luxembourg	2	0	0	1	0	0	0	0	0	2	0	0
Macedonia	1	1	1	1	0	0	0	0	0	0	0	2
Netherlands	1	0	0	1	0	0	2	0	0	1	0	0
Slovakia	1	0	0	0	0	0	1	2	0	1	1	0
Slovenia	1	0	0	0	1	0	0	1	0	0	1	0
Sweden	5	0	2	0	0	0	0	0	0	1	0	0
Number of countries	12	1	5	5	6	3	5	5	4	9	6	2

Table 4 (continued)

	Number of correlations between item and selected outcomes that *increased* in 2021/22 relative to 2017/18						Number of correlations between item and selected outcomes that *increased* in 2017/18 relative to 2013/14					
	Holiday	Computer	Car	Bedroom	Bathroom	Dishwasher	Holiday	Computer	Car	Bedroom	Bathroom	Dish-washer
Albania	0	1	0	0	0	0	2	0	0	3	1	3
Austria	0	3	0	0	1	0	0	1	2	3	0	0
Belgium (Flemish)	0	3	1	3	2	0	1	3	2	2	0	2
Croatia	0	1	0	0	2	0	2	0	0	1	0	0
Czech Republic	0	3	0	0	0	0	5	0	1	0	0	0
Denmark	0	1	1	1	2	0	0	0	0	1	0	1
England	0	1	0	0	1	1	3	2	0	1	1	2
Estonia	0	1	0	0	1	0	1	2	1	1	1	1
France	0	0	1	0	2	0	0	1	1	0	1	1
Hungary	0	1	1	0	1	2	0	0	0	0	0	0
Luxembourg	0	3	3	2	1	2	1	0	0	0	0	0
Macedonia	0	1	0	0	0	0	0	0	0	2	0	1
Netherlands	0	0	0	0	1	0	1	2	0	0	0	0
Slovakia	0	2	1	1	0	0	1	0	0	0	0	0
Slovenia	0	3	1	0	1	0	1	0	1	1	4	1
Sweden	0	0	0	0	1	1	1	0	0	1	1	0
Number of countries	0	13	7	4	12	4	11	6	6	10	6	8

Table 5 Summary scale criterion validity 2022, by country

	Correlations between six-item FAS-III scale and selected outcomes										Number of *decreased* correlations when omitting item…			Number of *increased* correlations when omitting item…		
	Mother employment	Father employment	Life satisfaction	Psychosomatic complaints	Moderate-to-vigorous physical activity	Vigorous physical activity	Fruit consumption	Vegetable consumption	Talking to father	Talking to mother	Holiday	Computer	Both	Holiday	Computer	Both
Albania	**0.17*** **	0.34***	0.16***	-0.01	0.11***	0.09***	0.09***	0.04**	0.09***	0.05**	0	1	1	0	0	0
Austria	0.30***	0.33***	**0.17*** **	-0.06**	0.13***	0.14***	**0.10*** **	**0.08*** **	**0.11*** **	**0.10*** **	4	0	5	0	0	0
Belgium (Flemish)	0.27***	0.30***	**0.18*** **	-0.08***	**0.15*** **	0.17***	**0.12*** **	0.13***	0.11***	0.08***	2	0	3	0	0	0
Croatia	0.18***	0.31***	**0.13*** **	-0.01	**0.12*** **	0.12***	0.09***	0.07***	0.08***	0.03	0	0	2	0	0	0
Czech Republic	0.16***	0.20***	**0.12*** **	-0.04**	**0.17*** **	**0.14*** **	**0.13*** **	**0.12*** **	**0.07*** **	**0.06*** **	7	0	6	0	0	0
Denmark	0.27***	0.31***	0.12***	-0.05*	**0.12*** **	**0.16*** **	**0.08*** **	0.10***	0.10***	0.09***	2	0	3	0	0	0
Estonia	0.11***	0.17***	0.16***	-0.08***	0.14***	0.13***	**0.13*** **	0.10***	0.13***	0.13***	1	0	1	0	0	0
France	0.30***	0.24***	0.10***	-0.05**	0.15***	0.16***	**0.15*** **	0.15***	0.08***	**0.06*** **	2	0	2	1	0	1
Hungary	0.20***	0.26***	0.17***	-0.11***	0.18***	0.15***	**0.19*** **	**0.15*** **	0.11***	0.11***	0	0	2	0	0	0
Luxembourg	0.25***	0.25***	0.16***	-0.06**	**0.24*** **	0.20***	**0.13*** **	**0.16*** **	0.07***	0.09***	2	0	3	0	0	0
Netherlands	0.20***	0.24***	0.09***	-0.05*	0.12***	**0.16*** **	**0.12*** **	**0.13*** **	0.11***	0.09***	2	0	3	0	0	0
Slovakia	0.24***	0.29***	0.06***	-0.04*	0.14***	0.13***	**0.17*** **	**0.13*** **	n.a.	n.a.	1	0	2	0	0	0
Slovenia	0.31***	0.30***	0.05***	-0.02	**0.15*** **	**0.13*** **	0.10***	0.08***	**0.07*** **	0.07***	3	0	0	0	0	0
Sweden	0.36***	0.35***	0.06***	0.00	0.14***	0.16***	**0.08*** **	0.07***	0.07***	0.05**	1	0	1	0	0	0
Macedonia	**0.14*** **	0.35***	0.08***	-0.02	0.13***	0.10***	0.14***	**0.14*** **	0.06**	0.07***	0	1	2	0	0	0
England	0.15***	0.29***	0.14***	-0.06**	0.17***	0.18***	0.21***	0.22***	0.07***	0.09***	0	0	0	0	0	0
Number of countries											11	2	14	1	0	1

Boldface correlations denote that respective correlation decreased in an adjusted FAS-scale where the holiday and/or computers item was/were omitted

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

n.a. = not applicable because talk to father/mother was not assessed

out of 16 countries, omitting the holiday item from the scale decreased correlations between family affluence and one to seven outcomes. In two countries, omitting the computer item decreased the correlation with one outcome. In 14 out of 16 countries, omitting both items decreased the correlation with at least one outcome. Only in one country, removing the holiday item from the scale strengthens a correlation between family affluence and an outcome. The correlations between family affluence and all selected outcomes using different FAS-operationalizations can be found in the Supplement (Table S7a-p).

Overall, in most countries, the criterion validity of the holiday item became weaker in 2021/22 compared to 2017/18. This seemed to be specific of 2021/22, because this occurred to a lesser extent between 2013/14 and 2017/18. Nevertheless, the scale criterion validity of the FAS in 2021/22 was worse in most countries when omitting the holiday item from the scale, which rejects Hypothesis 3. Contrary to expectations, the criterion validity of the computer item became stronger in 2021/22. However, omitting the computer item from the scale did not affect the criterion validity of the scale in 2021/22 in most countries, again rejecting Hypothesis 3.

4 Discussion

Using nationally representative HBSC data of 247,503 adolescents from 16 European countries, the present study compared the measurement properties of the six-item FAS-III scale during the COVID-19 pandemic (2021/22) with its properties before the pandemic (2013/14 and 2017/18). Specifically, we focused on the functioning of the holiday and computer items, which were expected to have been affected by the pandemic-related social and economic changes.

Overall, findings suggest that the functioning of the computer item and especially the holiday item, was less accurate during the pandemic than before although, both items still seem informative for the measurement of adolescents' family affluence. More specifically, firstly, we found that the holiday and computer item contributed more strongly to decreases in *internal consistency* during the pandemic than other FAS-items, and this applied especially to the holiday item, which is in line with Hypothesis 1. However, internal consistency was still acceptable in all 16 countries. Secondly, in accordance with Hypothesis 2, the item thresholds of the holiday and computer item were not *measurement invariant* in all countries, particularly the holiday item thresholds. This threshold variance indicated that during the pandemic, higher scores on the holiday item (i.e., having travelled more frequently abroad) reflected higher levels of family affluence, while higher scores on the computer item (i.e., having more computers) reflected lower levels of family affluence than in earlier years. Yet, the item factor loadings of the scale during the pandemic were comparable to the factor loadings before the pandemic in all countries. Thirdly, correlations between the holiday item (but not the computer item) and health-related outcomes were weaker during than before the pandemic, but were mostly still present in the expected direction. Hence, removing the holiday item from the FAS-III decreased the *criterion validity* of the total scale in most countries, thereby rejecting Hypothesis 3.

These findings inform future studies on adolescent socioeconomic health inequalities that use the six-item FAS-III scale. The results suggest that this scale is a suitable tool to study associations between SES and health-related outcomes during the pandemic. The scale retains sufficient reliability and criterion validity in 2021/22 when IPC measures were in place, and its one-factor model showed good to excellent model fit. Findings also imply that the FAS-III allows for reliable comparisons of the strength of the associations between family affluence and outcomes before and during the pandemic, as the factor loadings of the scale did not vary over time (Bowen & Masa, 2015; Van de Schoot et al., 2012). This comparison is of crucial importance to respond to concerns about exacerbating socioeconomic health inequalities among youth as a consequence of both the pandemic and its IPC measures (Lundström, 2022). In doing so, it is critical to rely on valid measures of adolescent SES. Furthermore, the finding that the FAS-III is suitable to measure SES during the pandemic among representative large groups of adolescents across many European countries participating in the HBSC study provides a strong indication that assessments of the FAS during the pandemic in other studies than HBSC also likely measure adolescent SES accurately.

The limited influence of the pandemic on the holidays FAS-III item might be because national measures related to travelling abroad were only implemented for short periods of time (Summan & Nandi, 2022), providing adolescents opportunities to go on family holidays in the year before survey participation. Indeed, substantial groups of adolescents reported going on family holidays in the past 12 months, regardless of their month of survey participation. With respect to the computer item, the distribution of digital devices to adolescents to facilitate home schooling was possibly specific to particular regions within countries as a result of regional policies, and possibly even specific to certain groups of adolescents, such as those with limited material resources. As such, pandemic-induced noise in the measurement of family affluence probably remained limited. In fact, in almost all countries, correlations between the computer item and health outcomes became stronger in 2021/22 compared to 2017/18, suggesting improved criterion validity. This may, however, be related to the crucial role that technology had during the pandemic rather than to improved validity. When physical contacts were limited by IPC measures, computers were one of the main tools to maintain social relationships (Canale et al., 2022). As such, the correlation with health outcomes may have become stronger.

However, some caution to the use of FAS-III is warranted. The observed inconsistent thresholds over time limit reliable mean comparisons of family affluence levels before and during the pandemic (Bowen & Masa, 2015; Van de Schoot et al., 2012). Consequently, comparing absolute levels of for example health behaviors by specific levels of family affluence is also restricted. In most countries, non-invariance of the holiday item thresholds indicated that going on holiday (once or more) in 2021/22 reflected higher levels of family affluence than in earlier years. Therefore, it seems that particularly adolescents from highly affluent families were most likely to go on holiday abroad during the pandemic. Also, half of the investigated countries showed threshold non-invariance of the computer item, whereby

having computers in the household represented lower levels of family affluence in 2021/22 than in earlier years. This finding is in line with the idea that computers were provided to those with a low SES during the pandemic. Removing the holiday and computer item from the FAS-III to reliably compare mean levels of FAS-III before and during the pandemic does not overcome bias because other items also show threshold non-invariance, although to a lesser extent. However, it has been put forward that it is justified to compare means when at least two items are constrained to be invariant (Byrne et al., 1989). All countries showed two or more time-invariant items and therefore mean comparisons of family affluence over time may still be warranted. Nevertheless, when doing so, it is important to acknowledge the potential bias caused by partial measurement invariance as found in this study. In addition, the inconsistent thresholds of the holiday and computer item across waves imply that the observed changes in family holidays and computer ownership cannot fully be attributed to changes in family affluence: they likely also reflect travel bans, reluctance in travelling in order to avoid social contacts, and the distribution of laptops to facilitate home schooling.

4.1 Strengths and Limitations

The present study examined the potential impact of the COVID-19 pandemic on the measurement properties of the FAS-III scale by drawing on data from large representative samples of adolescents participating in the repeated cross-sectional HBSC survey before and during the pandemic. Furthermore, it enriches available validation studies on the FAS-III scale with information on the scale's item internal consistency and with detailed assessments of criterion validity and measurement invariance.

Despite these strengths, the findings should be interpreted with some limitations. Firstly, the sample is limited to 16 European countries, while typically HBSC studies include up to 51 countries from Europe and North America. Nevertheless, the included countries represent a diversity of geographical regions, income levels, and fieldwork periods covering varying degrees of implemented IPC measures. Thus, we expect our findings to be generalizable to other countries included in the 2021/22 HBSC study, as well as to studies outside HBSC that use the FAS-III in their research on adolescent health inequalities during the pandemic. Secondly, there was substantial variation in missing data across countries. Although our pairwise deletion approach mitigates some bias related to missing data (Enders & Bandalos, 2001), it may not be optimal when dealing with a large number of missing observations, particularly for analyses by country. Third, the observed alpha of the FAS items was between 0.60 and 0.70 in most countries. However, values of 0.70 or higher may be desired for acceptable internal consistency (Drost, 2011; Taber, 2018).

4.2 Conclusion

The present study revealed a limited impact of the COVID-19 pandemic on the measurement properties of the holidays and computers items from the FAS-III scale. The extent to which the functioning of the holiday and computer item

were affected differed by country, but overall, the scale continues to be sufficiently reliable and valid in 2021/22. Although mean differences of family affluence levels based on FAS-III before and during the pandemic should be interpreted with caution, the scale allows for reliable international comparisons of socioeconomic health inequalities before and during the pandemic. Studies using the FAS-III scale to investigate (changes in) socioeconomic health behaviors in context of the COVID-19 pandemic are considered important directions for future research.

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Data, Materials and/or Code Availability Scripts for all analyses can be consulted at https://osf.io/rvqew/. HBSC data of survey cycles 2013/14 and 2017/18 is available upon request. HBSC data of survey cycle 2021/22 is embargoed.

Declarations

Ethics Approval This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the institutional ethic committees from each participating country.

Consent Informed consent was obtained from all individual participants included in the study. Parents of respondents provided active or passive consent, depending on the country.

Competing Interests The authors have no relevant financial or non-financial interests to disclose.

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