Sociodemographic characteristics on behavioural risk factors of noncommunicable diseases in adolescents in Luxembourg

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Abstract

Background Non-communicable diseases (NCDs) accounted for 89% of deaths in Luxembourg in 2019, aligning with Europe's figures but exceeding the global average of 74%. Behaviours play a critical role in NCD management, with unhealthy lifestyles—like poor diets, physical inactivity, tobacco use, and alcohol consumption—posing significant risks, especially when combined. The present study aims to explore sociodemographic characteristics of adolescents presenting behavioural risks for NCDs in Luxembourg.

Methods A representative sample of 8117 adolescents (11-to-18-years-old) took part in the 2022 Health Behaviour in School-aged Children (HBSC) Luxembourg survey. We measured physical inactivity, daily sugar consumption, cigarette use and alcohol consumption, and their combination (1, 2 or 3 ≥ risks). The sociodemographic characteristics investigated were sex, age, migration background, family structure and perceived wealth. Binomial logistic regression crude and adjusted were performed with sociodemographic characteristics for each risk behaviour. In addition, multinomial logistic regression crude and adjusted were used to analyse the association between the combination of risk behaviours and the sociodemographic information of the adolescents in Luxembourg.

Results Girls had higher odds of physical inactivity (OR = 2.06) than boys, and older age groups exhibited elevated odds of physical inactivity (OR = 2.99), cigarette smoking (OR = 25.00), and alcohol consumption (OR = 35.56). Migration background emerged as a protective factor against alcohol consumption (parents' migration OR = 0.60; self-immigrated OR = 0.45) but a risk factor for physical inactivity (parents' migration OR = 1.50; self-immigrated OR = 1.72). Adolescents who did not live with both parents were more likely to be physically inactive (OR = 1.37), consume sugar daily (OR = 1.33), smoke cigarettes (OR = 1.26) and consume alcohol (OR = 1.80). Adolescents that reported their families were not well off had higher odds to be physically inactive (OR = 2.12) and to consume sugar daily (OR = 1.39). The simultaneity of risk behaviours reveals a worrying trend of increasing risk with age, highlighting the need for preventive interventions throughout adolescence. Furthermore, the results in relation to family structure and perceived wealth highlights the complexity and interrelationship of these factors in adolescent behavioural health.

Conclusions The study provides guidance to create more effective interventions aiming to promote healthy behaviours in adolescents.

Keywords Physical inactivity, Eating behaviours, Addictive behaviours, Luxembourg, HBSC

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Background

Non-communicable diseases (NCDs) were responsible for 89% of total deaths in 2019 in Luxembourg, a prevalence similar to Europe's, but higher than the global average of 74% [1]. In modern society, NCDs have been

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a significant challenge to healthcare systems [2], as they result from multiple risk factors, including behavioural, metabolic, and environmental [3].

Behaviours are considered as modifiable risk factors and are crucial in the management of NCDs [2]. Hence, their promotion has been a priority for the past decade [4]. The main behavioural risk factors contributing to NCDs are unhealthy lifestyles, such as prolonged periods of unhealthy diets, physical inactivity, tobacco use, and alcohol consumption [3, 5, 6]. In Luxembourg, while there has been a decrease in daily sugary soft drinks consumption, tobacco use and alcohol consumption between 2010 and 2018 (with prevalence being 24%, 13%, 29%, respectively), daily sweets consumption has increased since 2014 reaching 25% in 2018 [7]. The combination of risk behaviours increases exponentially the probability of developing NCDs [5, 8]. The investigation of the simultaneous occurrence of NCDs risk behaviours is necessary, as it can guide the development of more effective strategies to prevent, manage, and alleviate the adverse health effects and premature mortality associated with these conditions [2].

Adolescence is a key phase in human development to enhance health. During this phase lasting habits are formed [9], including risks behaviours [10, 11], however insufficient attention is given to this population in comparison to adults [12]. Addressing social disparities that contribute to the emergence of these harmful behaviours is essential to ensure that prevention strategies are sensitive to inequalities [10, 13]. Neglecting risk factors for NCDs during adolescence can result in significant long-term impacts on adult's population health [11]. Additionally, identifying and understanding health inequalities based on social, economic or demographic factors can play a fundamental role in disease prevention in the future [14].

Luxembourg is a unique country in terms of social and cultural interactions. Situated in the heart of Europe, bordered by Germany, Belgium, and France, with residents from around 180 different nationalities [15] that bring various cultural backgrounds and socioeconomic statuses, Luxembourg is one of the great melting pots of Europe. Therefore, the objective of this study is to analyse social inequalities on behavioural risk factors for noncommunicable diseases among adolescents in Luxembourg.

Methodology

Study design

Health Behaviour in School-aged Children: WHO Collaborative Cross-National survey/study (HBSC) is a cross-national study of adolescent health and well-being. The survey is undertaken every four years with national representative samples, using a standardized questionnaire, following an international research protocol to ensure consistency in the data collection and processing [16]. Data from the HBSC Luxembourg Study 2022 were used to analyse the association of sex, migration background, family structure, perceived wealth, and age with physical inactivity, daily sugar consumption, cigarette smoking and alcohol consumption and the combination of these behaviours in adolescents in Luxembourg.

Sample and procedure

In Luxembourg, 8 538 adolescents aged 11 to 18 participated in the HBSC 2022 survey and responded to a paper-pencil questionnaire in class, during school hours. The questionnaire, originally developed in English, was translated to German and French using a translation/backtranslation process. Data was weighted according to the educational tracks and grade (classes were used as the primary sampling unit), ensuring that the sample distribution corresponds to the population and reducing possible bias from differences in participation rates. Ethical approval for the HBSC Luxembourg 2022 Survey was received (ERP 21−013 HBSC 2022), the parents/guardians of the adolescents were informed about the study through the school management and could refuse/consent their children participation.

Measures

Physical inactivity was assessed with the number of days in which the respondents considered themselves physically active for a total of at least 60 min per day, over the last seven days. The responses ranged from "0" to "7 days" in an eight-point-scale. "Physical inactivity" refers to the response "0 days" [17].

Daily sugar consumption was computed based on two questions in a seven-point scale, ranging from "never" to "more than once daily". For further analysis, the items were combined in one variable. "Daily sugar consumption" refers to those who reported sweets or soft drinks at least once a day.

Alcohol consumption was based on the number of days in which the respondents reported having drunk alcohol in the last 30 days. The response options varied between "never" to "30 days (or more)" in a seven-point-scale. "Alcohol consumption" includes all categories between "1 day" and "30 days or more".

Cigarette smoking was evaluated with the number of days in which the respondents stated they have smoked cigarettes in the last 30 days. The responses ranged on a seven-point-scale from "never" to "30 days (or more)". "Cigarette smoking" includes all categories between "1 day" and "30 days or more".

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Sociodemographic characteristics

Sex and age
Respondents answered if they were a boy or a girl and their month and year of birth. They were categorized in "11-12yo", "13-14yo", "15-16yo" and, "17-18yo".

Migration background
Respondents provided their own and their parents' country of birth. They were afterwards categorised as "no (recent) migration", "parental migration" or "self-migration".

Family structure
Respondents gave information on who they were living with. They were afterwards categorised as living with "both parents" and "other" family constellations.

Perceived wealth
Respondents answered on a five-point scale on how they perceived their own family's socioeconomic circumstances (i.e. how well off they thought their family was). The answers were categorised as "well-off", "average" or "not well-off".

Statistical analysis
Descriptive analyses were used to present the prevalence for each risk behaviour in total and by sociodemographic characteristics. Inferential analysis was conducted to investigate the relationship between risk behaviours for NCDs and sociodemographic characteristics. Binary logistic regression models were used to examine how behaviours such as physical inactivity, daily sugar consumption, cigarette smoking in the last 30 days, and alcohol consumption in the last 30 days were associated with sociodemographic characteristics. Adjusted models were used to account for potential confounding factors.

A multinomial logistic regression analysis was performed to assess combinations of risk behaviours. The reference category was 'no risk behaviour', the other categories were 'one risk behaviour', 'two risk behaviours', and 'three or more risk behaviours'. The independent variables were the sociodemographic characteristics (migration background, family structure and perceived wealth). Once again, adjusted models incorporated the sociodemographic variables associated in the crude models to account for potential additional influences. Statistical analysis was conducted using SPSS version 28 [18], with a significance level of .05 for all tests.

Table 1 Characteristics of the sample of the Health Behaviours School-aged children (HBSC) 2022 survey Luxembourg (*n* = 8538)

	Unweighted *n* (%)	Weighted *n* (%)
Total	8538 (100.0%)	8415 (100.0%)
Sex		
Boy	4327 (51.1%)	4316 (51.7%)
Girl	4140 (48.9%)	4029 (48.3%)
Age		
11–12 yo	2174 (25.5%)	2165 (25.7%)
13–14 yo	2344 (27.5%)	2366 (28.1%)
15–16 yo	2390 (28.0%)	2287 (27.2%)
17–18 yo	1630 (19.1%)	1597 (19.0%)
Migration background		
No (recent) migration	2160 (26.3%)	2095 (25.9%)
Parental migration	4009 (48.7%)	3924 (48.5%)
Self-migration	2059 (25.0%)	2065 (25.5%)
Family structure		
Both parents	5355 (66.5%)	5212 (65.9%)
Other	2698 (33.5%)	2696 (34.1%)
Perceived wealth		
Well off	4501 (54.3%)	4397 (53.8%)
Average	3270 (39.4%)	3239 (39.6%)
Not well off	523 (6.3%)	535 (6.6%)

Results
The characteristics of participants of the HBSC Luxembourg 2022 survey are presented in Table 1.

The weighted sample presented a balanced distribution between boys (51.7%) and girls (48.3%). The age groups were well represented 25.7% were aged 11–12 years, 28.1% aged 13–14 years, 27.2% aged 15–16 years, and 19.0% aged 17–18 years. Regarding migration background, 25.9% reported no recent migration, 48.5% had parental migration, and 25.5% were self-migrants. Most participants (65.9%) lived with both parents, while 34.1% lived in other family structures. Regarding perceived wealth, 53.8% considered themselves well off, 39.6% average, and 6.6% not well-off. Table 2 presents the prevalence of risk factors for non-communicable diseases (NCDs) in adolescents in Luxembourg stratified by sociodemographic characteristics.

Gender disparities were evident in physical inactivity only, with girls demonstrating higher rates (7.1%) compared to boys (3.7%). Most risk behaviours increased with age. The more prominent increase being of alcohol consumption (5.6% within 11-12yo and 57.4% within 17-18yo). Adolescents who were living in other (than both parents) family constellations had higher prevalence of all risk factors analysed, notably alcohol consumption (32.5%). Perceived wealth disparities were also observed,

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Table 2 Prevalence of risk factors for NCDs in adolescents in Luxembourg, stratified by sociodemographic characteristics

	Physical inactivity	Daily sugar consumption	Alcohol consumption	Cigarette smoking
Total	433 (5.3%)	940 (11.1%)	2166 (27.3%)	899 (11.3%)
Sex				
Boy	154 (3.7%)	503 (11.9%)	1117 (27.9%)	440 (10.9%)
Girl	276 (7.1%)	463 (11.6%)	1022 (26.8%)	451 (11.8%)
Age				
11–12 yo	54 (2.6%)	247 (11.6%)	112 (5.6%)	21 (1.0%)
13–14 yo	105 (4.6%)	308 (13.2%)	310 (14.1%)	143 (6.5%)
15–16 yo	145 (6.5%)	256 (11.3%)	875 (40.4%)	318 (14.6%)
17–18 yo	129 (8.3%)	165 (10.5%)	869 (57.4%)	417 (27.5%)
Migration background				
No (recent) migration	73 (3.6%)	249 (12.0%)	702 (35.5%)	238 (11.9%)
Parental migration	209 (5.5%)	444 (11.4%)	960 (25.9%)	420 (11.3%)
Self-migration	136 (6.8%)	231 (11.3%)	457 (23.6%)	225 (11.5%)
Family structure				
Both parents	229 (4.5%)	542 (10.5%)	1280 (25.8%)	454 (9.1%)
Other	177 (6.8%)	358 (13.4%)	809 (32.5%)	411 (16.4%)
Perceived wealth				
Well off	195 (4.6%)	488 (11.2%)	1110 (26.9%)	436 (10.5%)
Average	170 (5.4%)	374 (11.7%)	866 (28.4%)	371 (12.0%)
Not well off	57 (10.9%)	80 (15.1%)	165 (32.6%)	83 (16.6%)

adolescents not well-off presented higher prevalence across all risk factors analysed.

Table 3 presents the odds ratios (OR) and associated *p*-values in crude and adjusted models for the association between behavioural risk factors and sociodemographic characteristics.

The adjusted models revealed intricate associations between sociodemographic factors and various risk behaviours among adolescents in Luxembourg. In terms of physical inactivity, gender disparities persisted, with girls having significantly higher odds than boys of being physically inactive (OR = 2.06, 95%CI = 1.66–2.56). Age plays a pivotal role, with odds increasing in older age groups, particularly in the 17-18yo (OR = 2.99, 95%CI = 2.13–4.21). Migration background showed nuanced dynamics, with self-migration having the highest odds of physical inactivity (OR = 1.72, 95%CI = 1.27–2.34). Family structure and perceived wealth contributed significantly, with adolescents living in other (than both parents) family constellations (OR = 1.37, 95%CI = 1.11–1.69) and not well-off (OR = 2.12, 95%CI = 1.52–2.95) being associated with higher odds of physical inactivity.

In terms of daily sugar consumption, family structure and perceived wealth played substantial roles. Increased odds were observed for adolescents in other family constellations (OR = 1.33, 95%CI = 1.15–1.54), and not well off (OR = 1.39, 95%CI = 1.06–1.81). No

significant association was found in relation to sex, age, and migration background.

For alcohol consumption, age-related patterns were evident, with substantially increased odds in older age groups (OR$_{15-16yo}$ = 12.13, 95%CI = 9.74–15.11; OR$_{17-18yo}$ = 25.00, 95%CI = 19.30–31.40). Migration background introduced intriguing dynamics, with lower odds for adolescents with parental migration (OR = 0.60, 95%CI = 0.53–0.69) and self-migration (OR = 0.45, 95%CI = 0.39–0.54). Family structure was associated with alcohol consumption with adolescents living in other family constellations presenting a higher likelihood for alcohol consumption (OR = 1.26, 95%CI = 1.12–1.43) than those living with both parents.

Regarding smoking behaviour, age remained a key determinant, with higher probabilities of demonstrating such behaviours in older age groups (OR$_{15-16yo}$ = 15.94, 95%CI = 9.99–25.43; OR$_{17-18yo}$ = 35.56, 95%CI = 22.32–56.63). In relation to family structure, findings were similar to those of alcohol consumption, with adolescents living in other family constellations presenting higher odds of cigarette smoking (OR = 1.80, 95%CI = 1.54–2.09).

Table 4 presents odds ratios in both crude and adjusted models for the association between simultaneity of behavioural risk factors and sociodemographic factors.

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Table 3 Association between risk factors and sociodemographic characteristics in adolescents in Luxembourg

	Physical inactivity		Daily sugar consumption		Alcohol consumption		Cigarette smoking	
	Crude	Adjust	Crude	Adjust	Crude	Adjust	Crude	Adjust
	OR	OR	OR	OR	OR	OR	OR	OR
	(95%CI)	(95%CI)	(95%CI)	(95%CI)	(95%CI)	(95%CI)	(95%CI)	(95%CI)
Sex								
Boy	1	1	1		1		1	
Girl	1.97‡	2.06‡	0.97		0.94		1.09	
	(1.61–2.42)	(1.66–2.56)	(0.85–1.11)		(0.85–1.04)		(0.95–1.25)	
Age								
11-12yo	1	1	1		1	1	1	1
13-14yo	1.81‡	1.58 ‡	1.16		2.98‡	3.09‡	6.65‡	7.04‡
	(1.30–2.52)	(1.11–2.49)	(0.97–1.39)		(2.23–3.50)	(2.44–3.91)	(4.12–10.34)	(4.65–11.41)
15-16yo	2.61‡	2.37‡	0.97		11.54‡	12.13‡	16.19‡	15.94‡
	(1.90–3.58)	(1.70–3.31)	(0.81–1.17)		(9.36–14.22)	(9.74–15.11)	(10.39–25.23)	(9.99–25.43)
17-18yo	3.37‡	2.99‡	0.9		22.93‡	25.00‡	35.89‡	35.56‡
	(2.44–4.67)	(2.13–4.21)	(0.73–1.10)		(18.47–28.46)	(19.3–31.4)	(23.07–55.84)	(22.32–56.63)
Migration background								
No (recent) migration	1	1	1		1	1	1	
Parental migration	1.57‡	1.50‡	0.95		0.64‡	0.60‡	0.94	
	(1.19–2.06)	(1.14–1.99)	(0.80–1.12)		(0.57–0.72)	(0.53-0.069)	(0.80–1.12)	
Self-migration	1.98‡	1.72‡	0.94		0.56‡	0.45‡	0.96	
	(1.48–2.64)	(1.27–2.34)	(0.77–1.13)		(0.49–0.64)	(0.39–0.54)	(0.79–1.17)	
Family structure								
Both parents	1	1	1	1	1	1	1	1
Other	1.54‡	1.37†	1.33†	1.33‡	1.38‡	1.26‡	1.95‡	1.80‡
	(1.26–1.89)	(1.11–1.69)	(1.15–1.53)	(1.15–1.54)	(1.24–1.53)	(1.12–1.43)	(1.69–2.25)	(1.54–2.09)
Perceived wealth								
Well off	1	1	1	1	1	1	1	1
Average	1.19	1.03	1.05	1.02	1.07	0.93	1.16‡	0.99
	(0.96–1.47)	(0.93–1.29)	(0.91–1.21)	(0.88–1.19)	(0.97–1.19)	(0.83–1.06)	(1.00–1.34)	(0.84–1.16)
Not well off	2.54‡	2.12‡	1.41*	1.39†	1.31†	1.12	1.69‡	1.09
	(1.86–3.47)	(1.52–2.95)	(1.09–1.82)	(1.06–1.81)	(1.08–1.60)	(0.89–1.41)	(1.31–2.18)	(0.82–1.44)

95CI 95% confidence interval, *OR* odds ratio

*$p < .05$, †$p < .005$, ‡$p < .001$

Among the total of 7488 adolescents who took part in this study (89.3% response rate), 59.9% reported no risk behaviour, while 27.1% have a single risk behaviour for NCDs. A substantial rise in risk behaviours is observed as age increases ($OR_{13-14yo} = 1.54$, 95%CI = 1.30–1.83; $OR_{15-16yo} = 4.15$, 95%CI = 3.53–4.89 and $OR_{17-18yo} = 6.55$, 95%CI = 5.46–7.87). The migration background also plays a role, with lower risks behaviours being identified among those with parental migration (OR = 0.72, 95%CI = 0.63–0.82) and self-migration (OR = 0.61, 95%CI = 0.52–0.72), compared to those with no (recent) migration. The family structure (OR = 1.26, 95%CI = 1.11–1.42) also shows a significant association with a single risk behaviour. Sex and

perceived wealth do not show significant associations with a single risk behaviour in the adjust model.

A total 10.8% presented two risk behaviours for NCDs. Age proves to be a significant factor, revealing increased risk in older age groups ($OR_{13-14yo} = 3.36$, 95%CI = 2.30–4.90; $OR_{15-16yo} = 10.57$, 95%CI = 7.41–15.07; $OR_{17-18yo} = 31.44$, 95%CI = 22.01–44.91). Also, the influence of a recent migration background is demonstrated by a decrease in the risk among individuals with parental migration (OR = 0.71, 95%CI = 0.58–0.87) and self-migration (OR = 0.60, 95%CI = 0.47–0.76), in contrast to those with no (recent) migration. Family structure exhibited a noteworthy association, with adolescents from other family constellations showing

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Table 4 Association between cumulative risk behaviours and sociodemographic characteristics in adolescents in Luxembourg

	No Risk Vs. One Risk			No Risk Vs. Two Risks			No Risk Vs. ≥Three Risks		
	n (%)	Crude OR (95%CI)	Adjust OR (95%CI)	*n* (%)	Crude OR(95%CI)	Adjust OR(95%CI)	*n* (%)	Crude OR(95%CI)	Adjust OR(95%CI)
Total	2032 (27.1)			806 (10.8)			163 (2.2)		
Sex									
Boy	1013 (26.8)	1		392 (10.4)	1		76 (2.0)	1	
Girl	1000 (27.4)	1.05 (0.95–1.17)		405 (11.1)	1.10 (0.94–1.28)		86 (2.4)	1.20 (0.88–1.64)	
Age									
11–12 yo	304 (16.0)	1	1	41 (2.2)	1	1	2 (0.1)	1	1
13–14 yo	430 (20.8)	1.49‡ (1.26–1.75)	1.54‡ (1.30–1.83)	124 (6.0)	3.17‡ (2.21–4.54)	3.36‡ (2.30–4.90)	36 (1.7)	23.52‡ (4.81–115.17)	22.91‡ (4.67–112.42)
15–16 yo	748 (36.3)	3.90‡ (3.34–4.56)	4.15‡ (3.53–4.89)	275 (13.3)	10.61‡ (7.57–14.86)	10.57‡ (7.41–15.07)	58 (2.8)	57.87‡ (11.97–279.76)	55.40‡ (11.44–268.21)
17–18 yo	551 (38.0)	6.07‡ (5.10–7.22)	6.55‡ (5.46–7.87)	365 (25.2)	29.72‡ (21.19–41.69)	31.44‡ (22.01–44.91)	68 (4.7)	142.39‡ (29.50–687.16)	121.25‡ (25.02–587.58)
Migration background									
No (recent) migration	598 (31.4)	1	1	239 (12.6)	1	1	36 (1.9)	1	1
Parental migration	922 (26.2)	0.74‡ (0.65–0.84)	0.72‡ (0.63–0.82)	340 (10.2)	0.72† (0.60–0.86)	0.71‡ (0.58–0.87)	83 (2.3)	1.09 (0.73–1.62)	0.99 (0.66–1.49)
Self-migration	455 (24.9)	0.69‡ (0.59–0.80)	0.61‡ (0.52–0.72)	189 (10.3)	0.71‡ (0.58–0.88)	0.60‡ (0.47–0.76)	41 (2.2)	1.01 (064-1.60)	0.43 (0.43–1.12)
Family structure									
Both parents	1249 (26.3)	1	1	447 (9.4)	1	1	74 (1.6)	1	1
Other	690 (29.3)	1.31‡ (1.17–1.47)	1.26‡ (1.11–1.42)	325 −13.8	1.72‡ (1.47–2.02)	1.62‡ (1.36–1.92)	84 (3.6)	2.69‡ (1.96–3.71)	2.46‡ (1.76–3.44)
Perceived wealth									
Well off	1045 (26.7)	1	1	390 (10.0)	1	1	77 (2.0)	1	1
Average	811 (27.7)	1.09 (0.97–1.21)	1.01 (0.90–1.14)	344 (11.8)	1.24* (1.06–1.45)	1.08 (0.91–1.29)	51 (1.7)	0.93 (0.65–1.33)	0.70 (0.48–1.02)
Not well off	140 (29.3)	1.32* (1.06–1.65)	1.26 (0.99–1.61)	61 (12.8)	1.55† (1.15–2.10)	1.23 (0.88–1.73)	33 (6.9)	4.22‡ (2.75–6.48)	2.94‡ (1.84–4.70)

95CI 95% confidence interval, *OR* odds ratio

*p < .05, †p < .005, ‡ p < .001

a higher likelihood of presenting two risk behaviours (OR = 1.62, 95%CI = 1.36–1.92).

Three or more risk behaviours were reported by 2.2% of the adolescents. Age emerges as a significant factor, with substantially increased risks in older age groups (OR$_{13-14yo}$ = 22.91, 95%CI = 4.67–112.42, to OR$_{17-18yo}$ = 121.25, 95%CI = 25.02–587.58). Family structure was associated with three or more risks, with adolescents living in other family constellations presenting higher odds ratio (OR = 2.46, 95%CI = 1.76–3.44) than those living with both parents. The perceived wealth presented association, revealing higher odds among not well-off adolescents (OR = 2.94, 95%CI = 1.84–4.70). Sex and migration background did not present association with three or more risk behaviours.

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Discussion

This study aimed to analyse social inequalities on behavioural risk factors for non-communicable diseases (NCDs) among adolescents in Luxembourg. More specifically, we explored the association between physical inactivity, daily sugar consumption, alcohol consumption and cigarette smoking, on one hand, and sex, age, migration background, family structure and perceived wealth, on the other hand. Our results indicated that alcohol consumption (27.3%) and cigarette smoking (11.3%) were the most prevalent risk behaviours. Regarding the combination of risk behaviours for NCDs, 27.1% of the participants reported one single lifestyle related risk behaviour for NCDs, while 10.8% reported two and 2.2% three or more risk behaviours.

Social inequalities varied according to the behaviours. Sex had the lowest number of behaviours associated to it, increased age had an exponential association, migration background and perceived wealth presented mixed patterns, while family structure exhibited a similar pattern across behaviours.

Sex presented an association with physical inactivity only. Girls presented a higher probability to be physical inactive compared to boys. Similar findings have been reported in Europe for decades [19]. This behaviour can be widely explained by the cultural activities traditionally carried out during the leisure time, such as collective sports for boys and reading for girls [20] as boys could have wider options of leisure activities than for girls in high income countries [21]. Besides that, no other risk behaviours presented an association with sex. Similar findings were already observed in other countries, with no sex difference found in relation to daily sugar consumption [22], cigarette smoking [23, 24] and alcohol consumption [25]. It is known that while boys tend to consume more sugar-sweetened beverages [26], girls appear to consume more sweets [27] and Luxembourg is no exception [28]. As in our study adolescents reported the daily consumption of sweets or soft drinks, we can speculate that the non-gendered finding concerning daily sugar consumption might be due to this fact. Regarding cigarette smoking and alcohol consumption, both behaviours are decreasing in the world [24, 25, 29–31], which may be due to the implementation of policies and the negative perception of substance use [25]. Nonetheless, the decrease in boys' behaviours is more prominent than in girls, narrowing the gender gap [25, 31, 32]. That is especially true in countries with high gender equality [33], such as Luxembourg [34], as in countries with high gender equality girls may feel less constraints about the gender role and barriers to use substances [33].

Age was associated with physical inactivity, alcohol consumption and cigarette smoking, with odds increasing significantly in older age groups. Regarding physical inactivity, as adolescents progress in school and reach the end of secondary school, there is an increase in participation in extracurricular activities that could explain the decrease of physical activity [35]. Adolescents have more difficulty perceiving risks than adults [36], higher vulnerability to peer pressure [37] and are more sensitive to instant rewards than adults [38], increasing the likelihood of smoking and consuming alcohol during adolescence. The importance of age is also highlighted when focusing on the simultaneity of risk factors. Previous investigations indicated that once one risk behaviour is adopted, there is a higher chance to adopt others in the future [39], stressing the need for preventive interventions throughout the course of adolescence.

Regarding the migration background, it is important to note that Luxembourg has one of the highest migration rates in Europe [40]. Near half (47.4%) of the population are immigrants. The highest proportion coming from Portugal, France and Italy respectively [41]. In Luxembourg, being an immigrant (self-migration or parental migration) is associated with increased odds of physical inactivity, but lower odds of alcohol consumption controlled by all the sociodemographic variables. Similar findings were observed in Belgium, a neighbouring country of Luxembourg, where migrant adolescents also presented lower odds of consuming alcohol controlled by socioeconomic status [42]. Therefore, migration background can be considered as a protective factor to alcohol consumption while as a risk factor to physical inactivity in Luxembourg. Due to these complex associations with each risk behaviours, migration background did not present an association with the combination of risk behaviours of NCDs. This lack of standard direction is a very important finding for the development of tailored preventive strategies.

Family structure showed an association with all risk behaviours and their simultaneity. Adolescents living in other family constellations presented higher odds of being physically inactive, consuming sugar daily, consuming alcohol and smoking cigarettes compared to those living with both parents, controlled by sociodemographic characteristics. The association between family structure and physical activity or sweet and soft drinks consumption may be partially explained by perceived wealth [22, 43, 44]. However, our study accounted for perceived wealth and the results suggest that this relationship is more complex. For instance, adolescents not living with both parents reported encountering more barriers to engage in physical activities and perceived less support from their parents, due to time constraints and family responsibilities [45]. A systematic review of reviews [46] found that a better or more positive support

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from family has a positive association for the practice of physical activity during the leisure time. In the literature, living with both parents played a protective role on daily sweets consumption and in alcohol consumption in other countries [22, 35]. Moreover, family structure differences could be explained by other mechanisms than socio-economic status [22, 43]. Adolescents living with a single parent are more likely to engage in substance use as they are less likely to have protective youth assets such as relationship with father, parental monitoring, use of time and school connectedness [47]. In France, an important border country with Luxembourg, it was found that what most influences adolescent smoking were parental smoking and family structure [48]. It is possible that similar influences could be found in Luxembourg, due to its geographical proximity.

Perceived wealth was also associated with risk factors, as adolescents from not well-off families have higher odds of physical inactivity and daily sugar consumption than their peers. These disparities may reflect social dynamics and contextual factors that influence physical activity and healthy food choices among young people [49, 50]. For instance, the food security, that reflect the access to sufficiently safe and nutritious food that meets their dietary needs and food preferences, can explain the results, as it presents an association with family income in Europe [51]. Interestingly, perceived wealth was not determinant to having a single, nor two risk behaviours, but only when considering three or more risk factor simultaneously. That is due to the fact that cigarette smoking and alcohol consumption, the two most prevalent behaviours, showed no significant association to perceived wealth. As such, when cumulative behaviours are taken into consideration, adolescents from low affluent families are more vulnerable to multiple simultaneous risk factors. It is important to note that in Luxembourg adolescents from a low affluent background were more prone to be overweight/obese [28], likely because of this increased vulnerability to simultaneous risk behaviours. Prevention programs aiming at this group already exist in the country and should be reinforced by considering the importance of understanding what is necessary to promote access to affordable healthier food options and by reducing the barriers for the physical activity practice.

This study was the first to investigate simultaneity patterns of four major NCD-related lifestyle risk factors among adolescents in Luxembourg. In addition, to our knowledge, this is the largest study providing prevalence estimates of four lifestyle risk factors and their combination patterns among adolescents aged 11–18 in the country. While this study offers valuable insights, it is essential to recognise its limitations. First, the cross-sectional design of the study does not allow for conclusions about cause-and-effect relations. In addition, the measures are self-reported and, as such, they are potentially affected by response bias such as social desirability and memory bias. Future research may benefit from longitudinal approaches to better understand trajectories of risk behaviours and analyse the factors that can contribute to the development of these behaviours.

Final considerations

Our findings suggest social inequalities in behavioural risk factors for non-communicable diseases (NCDs) among adolescents living in Luxembourg. The risk behaviours to NCDs that presented the higher prevalence among adolescents in Luxembourg were alcohol consumption and cigarette smoking. Among the sociodemographic variables, physical inactivity showed significant association with the highest number of variables, followed by cigarette smoking, alcohol consumption, and daily sugar consumption. The odds ratio for simultaneity of lifestyle risk factors associated to NCDs indicates an association with sociodemographic characteristics, especially increased age, and family structure (living in a family constellation other than with both parents). To conclude, this study provided more precise guidance to develop more effective interventions to promote healthy behaviours in adolescents in Luxembourg.

Declarations

Ethics approval and consent to participate
The HBSC 2022 Luxembourg study was approved by the Ethics Review Panel of the University of Luxembourg (ERP 21−013 HBSC 2022). Parents/guardians of these adolescents received an information letter about the survey as well as

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an informed consent form with the opportunity to refuse/consent their child. Informed consent was obtained from parents/guardians of all participants of the study.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

References

1. GBD 2019 Diseases and Injuries Collaborators. Global burden of 369 diseases and injuries in 204 countries and territories, 1990–2019: a systematic analysis for the global burden of Disease Study 2019. Lancet. 2020;396:1204–22. https://doi.org/10.1016/S0140-6736(20)30925-9.
2. Budreviciute A, Damiati S, Sabir DK, Onder K, Schuller-Goetzburg P, Plakys G, et al. Management and Prevention Strategies for non-communicable diseases (NCDs) and their risk factors. Front Public Health. 2020;8:574111. https://doi.org/10.3389/fpubh.2020.574111.
3. World Health Organization. Global status report on noncommunicable diseases 2010. Geneva: World Health Organisation; 2011 2010.
4. Global action plan for the prevention. And control of noncommunicable diseases, 2013–2020. Geneva, Switzerland: World Health Organization; 2013.
5. Uddin R, Lee E-Y, Khan SR, Tremblay MS, Khan A. Clustering of lifestyle risk factors for non-communicable diseases in 304,779 adolescents from 89 countries: a global perspective. Prev Med. 2020;131:105955. https://doi.org/10.1016/j.ypmed.2019.105955.
6. Bennett JE, Stevens GA, Mathers CD, Bonita R, Rehm J, Kruk ME, et al. NCD countdown 2030: worldwide trends in non-communicable disease mortality and progress towards sustainable development goal target 3.4. Lancet. 2018;392:1072–88. https://doi.org/10.1016/S0140-6736(18)31992-5.
7. Heinz A, van Duin C, Kern MR, Catunda C, Willems H. Trends from 2006–2018 in health behaviour, health outcomes and social context of adolescents in Luxembourg. Esch-sur-Alzette; 2020.
8. Stein CJ, Colditz GA. Modifiable risk factors for cancer. Br J Cancer. 2004;90:299–303. https://doi.org/10.1038/sj.bjc.6601509.
9. Darfour-Oduro SA, Buchner DM, Andrade JE, Grigsby-Toussaint DS. A comparative study of fruit and vegetable consumption and physical activity among adolescents in 49 low-and-Middle-Income Countries. Sci Rep. 2018;8:1623. https://doi.org/10.1038/s41598-018-19956-0.
10. Sawyer SM, Afifi RA, Bearinger LH, Blakemore S-J, Dick B, Ezeh AC, Patton GC. Adolescence: a foundation for future health. Lancet. 2012;379:1630–40. https://doi.org/10.1016/S0140-6736(12)60072-5.
11. Patton GC, Sawyer SM, Santelli JS, Ross DA, Afifi R, Allen NB, et al. Our future: a Lancet commission on adolescent health and wellbeing. Lancet. 2016;387:2423–78. https://doi.org/10.1016/S0140-6736(16)00579-1.
12. Akseer N, Mehta S, Wigle J, Chera R, Brickman ZJ, Al-Gashm S, et al. Non-communicable diseases among adolescents: current status, determinants, interventions and policies. BMC Public Health. 2020;20:1908. https://doi.org/10.1186/s12889-020-09988-5.
13. Viner RM, Ozer EM, Denny S, Marmot M, Resnick M, Fatusi A, Currie C. Adolescence and the social determinants of health. Lancet. 2012;379:1641–52. https://doi.org/10.1016/S0140-6736(12)60149-4.
14. World Health Organization. In: Organization WH, editor. Integrating the social determinants of health into health workforce education and training. Integrating the social determinants of health into health workforce education and training; 2023.
15. Peltier F, Klein C. Une population de plus en plus cosmopolite. Luxembourg; 2023.
16. Inchley J, Currie D, Samdal O, Jåstad A, Cosma A, Nic Gabhainn S, editors. Health Behaviour in School-aged Children (HBSC) Study Protocol: background, methodology and mandatory items for the 2021/22 survey.
17. WHO guidelines on physical activity and sedentary behaviour; 2020.
18. IBM Corp. IBM SPSS statistics for Windows. Armonk, NY: IBM Corp; 2021.
19. López-Fernández J, López-Valenciano A, Pearce G, Copeland RJ, Liguori G, Jiménez A, Mayo X. Physical inactivity levels of European adolescents in 2002, 2005, 2013, and 2017. Int J Environ Res Public Health. 2023. https://doi.org/10.3390/ijerph20043758.
20. Ferrar KE, Olds TS, Walters JL. All the stereotypes confirmed: differences in how Australian boys and girls use their time. Health Educ Behav. 2012;39:589–95. https://doi.org/10.1177/1090198111423942.
21. Ricardo LIC, Wendt A, Costa CS, Mielke GI, Brazo-Sayavera J, Khan A, et al. Gender inequalities in physical activity among adolescents from 64 global south countries. J Sport Health Sci. 2022;11:509–20. https://doi.org/10.1016/j.jshs.2022.01.007.
22. Fismen A-S, Smith ORF, Samdal O, Helleve A, Haug E. Associations between family structure and adolescents' food habits. Public Health Nutr. 2022;25:702–9. https://doi.org/10.1017/S1368980020004334.
23. Charrier L, van Dorsselaer S, Canale N, Baska T, Kilibarda B, Comoretto RI, et al. A focus on adolescent substance use in Europe, central Asia and Canada. Health Behaviour in School-aged Children international report from the 2021/2022 survey. Volume 3. Copenhagen: WHO Regional Office for Europe; 2024.
24. Meza R, Jimenez-Mendoza E, Levy DT. Trends in Tobacco Use among adolescents by Grade, Sex, and race, 1991–2019. JAMA Netw Open. 2020;3:e2027465. https://doi.org/10.1001/jamanetworkopen.2020.27465.
25. ESPAD Group. ESPAD Report 2019: Results from the European School Survey Project on Alcohol and Other Drugs. Luxembourg: EMCDDA Joint Publications, Publications Office of the European Union; 2020.
26. Vanderlee L, Manske S, Murnaghan D, Hanning R, Hammond D. Sugar-sweetened beverage consumption among a subset of Canadian youth. J Sch Health. 2014;84:168–76. https://doi.org/10.1111/josh.12139.
27. Inchley J, Currie D, Budisavljevic S, Torsheim T, Jåstad A, Cosma A, editors. Spotlight on adolescent health and well-being. Findings from the 2017/2018 Health Behaviour in School-aged children (HBSC)'survey in Europe and Canada. International report. Volume 1. Key findings: World Health Organization. Regional Office for Europe; 2020.
28. Mendes FG, Lopes Ferreira J, Residori C, Catunda C. Health behaviours of school-aged children in Luxembourg - Report on the Luxembourg HBSC Survey 2022; 2024.
29. Keyes KM, Kaur N, Kreski NT, Chen Q, Martins SS, Hasin D, et al. Temporal trends in alcohol, cannabis, and simultaneous use among 12th-grade U.S. adolescents from 2000 to 2020: differences by sex, parental education, and race and ethnicity. Alcohol Clin Exp Res. 2022;46:1677–86. https://doi.org/10.1111/acer.14914.
30. Catunda C, Mendes FG, Lopes Ferreira J. Risk behaviours in school-aged children in Luxembourg - Report on the Luxembourg HBSC Survey 2022; 2024.
31. Ma C, Xi B, Li Z, Wu H, Zhao M, Liang Y, Bovet P. Prevalence and trends in tobacco use among adolescents aged 13–15 years in 143 countries, 1999–2018: findings from the Global Youth Tobacco Surveys. Lancet Child Adolesc Health. 2021;5:245–55. https://doi.org/10.1016/S2352-4642(20)30390-4.
32. Jang JB, Patrick ME, Keyes KM, Hamilton AD, Schulenberg JE. Frequent binge drinking among US adolescents, 1991 to 2015. Pediatrics. 2017. https://doi.org/10.1542/peds.2016-4023.
33. Cosma A, Elgar FJ, de Looze M, Canale N, Lenzi M, Inchley J, Vieno A. Structural gender inequality and gender differences in adolescent substance use: a multilevel study from 45 countries. SSM - Popul Health. 2022;19:101208. https://doi.org/10.1016/j.ssmph.2022.101208.
34. European Institute for Gender Equality. Gender Equality Index 2023: Luxembourg. 2023. https://eige.europa.eu/modules/custom/eige_gei/app/content/downloads/factsheets/LU_2023_factsheet.pdf.
35. Chong KH, Parrish A-M, Cliff DP, Kemp BJ, Zhang Z, Okely AD. Changes in physical activity, sedentary behaviour and sleep across the transition from primary to secondary school: a systematic review. J Sci Med Sport. 2020;23:498–505. https://doi.org/10.1016/j.jsams.2019.12.002.
36. Reyna VF, Farley F. Risk and rationality in adolescent decision making: implications for theory, practice, and Public Policy. Psychol Sci Public Interest. 2006;7:1–44. https://doi.org/10.1111/j.1529-1006.2006.00026.x.

Glasgow: MRC/CSO Social and Public Health Sciences Unit, University of Glasgow; 2023.

Mendes *et al. BMC Public Health*   (2025) 25:586

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37. Steinberg L. Risk taking in Adolescence. Curr Dir Psychol Sci. 2007;16:55–9. https://doi.org/10.1111/J.1467-8721.2007.00475.X.

38. Kim-Spoon J, Deater-Deckard K, Holmes C, Lee J, Chiu P, King-Casas B. Behavioral and neural inhibitory control moderates the effects of reward sensitivity on adolescent substance use. Neuropsychologia. 2016;91:318–26. https://doi.org/10.1016/j.neuropsychologia.2016.08.028.

39. Arena R, Guazzi M, Lianov L, Whitsel L, Berra K, Lavie CJ, et al. Healthy lifestyle interventions to combat noncommunicable disease-a novel non-hierarchical connectivity model for key stakeholders: a policy statement from the American Heart Association, European Society of Cardiology, European Association for Cardiovascular Prevention and Rehabilitation, and American College of Preventive Medicine. Eur Heart J. 2015;36:2097–109. https://doi.org/10.1093/eurheartj/ehv207.

40. Eurostat. Statistics Explained. 2024. https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Migration_and_migrant_population_statistics. Accessed Apr 2024.

41. Klein C, Peltier F. La démographie luxembourgeoise en chiffres. Luxembourg; 2023.

42. Pedroni C, Dujeu M, Lebacq T, Desnouck V, Holmberg E, Castetbon K. Alcohol consumption in early adolescence: associations with sociodemographic and psychosocial factors according to gender. PLoS ONE. 2021;16:e0245597. https://doi.org/10.1371/journal.pone.0245597.

43. Pearson N, Biddle SJH, Gorely T. Family correlates of breakfast consumption among children and adolescents. A systematic review. Appetite. 2009;52:1–7. https://doi.org/10.1016/j.appet.2008.08.006.

44. Toftegaard-Støckel J, Nielsen GA, Ibsen B, Andersen LB. Parental, socio and cultural factors associated with adolescents' sports participation in four Danish municipalities. Scand J Med Sci Sports. 2011;21:606–11. https://doi.org/10.1111/j.1600-0838.2010.01093.x.

45. Quarmby T, Dagkas S, Bridge M. Associations between children's physical activities, sedentary behaviours and family structure: a sequential mixed methods approach. Health Educ Res. 2011;26:63–76. https://doi.org/10.1093/her/cyq071.

46. Garcia L, Mendonça G, Benedetti TRB, Borges LJ, Streit IA, Christofoletti M, et al. Barriers and facilitators of domain-specific physical activity: a systematic review of reviews. BMC Public Health. 2022;22:1964. https://doi.org/10.1186/s12889-022-14385-1.

47. Sanchez LM, Oman RF, Yang Y, Lensch T. Youth assets and Alcohol, Tobacco, and other Drug Use: the importance of Family structure. J Prev. 2024;45:391–403. https://doi.org/10.1007/s10935-024-00775-1.

48. Legleye S, Bricard D, Khlat M. Roles of parental smoking and family structure for the explanation of socio-economic inequalities in adolescent smoking. Addiction. 2023;118:149–59. https://doi.org/10.1111/add.16026.

49. Berger N, Cummins S, Smith RD, Cornelsen L. Have socio-economic inequalities in sugar purchasing widened? A longitudinal analysis of food and beverage consumer data from British households, 2014–2017. Public Health Nutr. 2021;24:1583–94. https://doi.org/10.1017/S136898002000505029.

50. Choi J, Lee M, Lee J, Kang D, Choi J-Y. Correlates associated with participation in physical activity among adults: a systematic review of reviews and update. BMC Public Health. 2017;17:356. https://doi.org/10.1186/s12889-017-4255-2.

51. Borch A, Kjærnes U. Food security and food insecurity in Europe: an analysis of the academic discourse (1975–2013). Appetite. 2016;103:137–47. https://doi.org/10.1016/j.appet.2016.04.005.

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