



Time trends in associations between neighbourhood and school characteristics and mental health problems among Dutch adolescents

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ABSTRACT

We investigated trends in associations between physical and social neighbourhood and school characteristics and adolescent mental health problems between 2005 and 2017. Nationally representative, repeated cross-sectional data collected in the Netherlands among primary (N = 5,871) and secondary school students (N = 20,778) were analysed through cross-classified multilevel models. Hardly any evidence was found for over-time changes in associations between neighbourhood and school characteristics and adolescent mental health problems. Findings showed that for both groups of students, only social characteristics within the two contexts were associated with adolescent mental health problems. For secondary school students, school effects were larger than neighbourhood effects, while the opposite was true for primary school students. Specifically, primary school students residing in more socially fragmented or lower socioeconomic status (SES) neighbourhoods, and lower SES schools, reported more conduct problems and peer relationship problems. For secondary school students, only the SES of the neighbourhood and the school was associated with all four aspects of mental health problems. Remarkably, the direction of the associations between neighbourhood/ school SES and adolescent mental health problems varied across the different mental health outcomes. More research is warranted to replicate our findings.

1. Introduction

There is mounting evidence that contextual characteristics of the living environment are related to adolescent mental health problems (Aldridge and McChesney, 2018; Minh et al., 2017). The most important out-of-home contexts for adolescents are the residential neighbourhood and the school, given adolescents' mobility restrictions and compulsory education (Allison et al., 1999; Browning et al., 2021). Various studies have demonstrated that both the physical and the social environment of the residential neighbourhood and school are associated with adolescent mental health problems (e.g., Aldridge and McChesney, 2018; Boen et al., 2020; Francesconi et al., 2022; Visser et al., 2021). To capture the physical environment of these contexts, we used greenspace and air pollution. Additionally, we assessed the social environment, by considering the socioeconomic status (SES) and social fragmentation for the neighbourhood context, and SES and school-level classmate support for the school context. It is important to assess all four characteristics simultaneously due to their interdependence (Jennings and Bamkole, 2019). Furthermore, it is crucial to include both contexts, as excluding

either the neighbourhood or the school context may lead to an "omitted context bias", wherein the variance of the missing context is mis-attributed to the included context due to (partially) overlapping contexts (Evans et al., 2016; Milliren et al., 2018). Previous studies showed that less greenspace, more air pollution, lower SES, more social fragmentation and less school-level classmate support are associated with more mental health problems among adolescents (Aldridge and McChesney, 2018; Boen et al., 2020; Forns et al., 2016; Mohai et al., 2011; Vanaken and Danckaerts, 2018; Visser et al., 2021; Zhang et al., 2020).

Despite these research efforts, some scholars questioned the importance of the neighbourhood in the lives of adolescents nowadays, since adolescents have been found to spend less time in their neighbourhood (Van Kempen and Wissink, 2014) and to have less contact with neighbours than before (Bartolini et al., 2013; Coumans and Schmeets, 2020). Although this question has been frequently raised (Andreotti, 2014; Mahmoudi Farahani, 2016; Van Kempen and Wissink, 2014), to our knowledge, it has not been empirically tested. To respond to this knowledge gap, we investigate time trends in associations between physical (i.e., greenspace and air pollution) and social (i.e., SES and

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social fragmentation/classmate support) characteristics of the residential neighbourhood and the school on adolescent mental health problems between 2005 and 2017 in the Netherlands.

1.1. Changes in the association between neighbourhood and school characteristics and adolescent mental health problems

We expected changes in associations with neighbourhood characteristics due to the following two societal changes. First, during the last decade, the use of the Internet and ownership of mobile phone has increased considerably. To illustrate, 76% of Dutch adolescents aged 12–15 had a mobile phone in 2012, which steadily increased to 98% in 2017 (CBS Statline, 2019). These technological developments may have facilitated adolescents to build and maintain relationships with peers outside their neighbourhood, making them less dependent on social contacts within their neighbourhood (Van Kempen and Wissink, 2014). Indeed, some studies suggest that face-to-face interactions which typically took place in neighbourhoods have been (partially) substituted by online contacts (Marshall et al., 2006; Oswald et al., 2020; Thulin and Vilhelmson, 2019). Second, there are indications that the level of protectiveness by parents towards their children has grown in the last two decades (Brussoni et al., 2012; Lee et al., 2021; Nelson, 2010; Pain, 2006). Protective parents may attempt to shield their children from neighbourhood threats by, for instance, monitoring the child's location or keeping them at home (LeMoyné and Buchanan, 2011; Visser et al., 2015). Consequently, such protective behaviour by parents may make children less able to roam the neighbourhood independently (Loebach and Gilliland, 2016; Parsons and Traunter, 2020).

Thus, due to fewer exposures to the neighbourhood context as a consequence of these two societal changes, adolescents may have less access to neighbourhood resources, such as social support from the neighbourhood, which can be helpful in preventing mental health problems. At the same time, adolescents may be less exposed to negative neighbourhood characteristics such as violence taking place in a deprived neighbourhood, which in turn may decrease mental health problems. Consequently, we hypothesized that the importance of the neighbourhood in the lives of adolescents has declined over time.

Regarding school characteristics, both decreasing and stable associations between school characteristics and adolescent mental health problems are plausible. Here, it is important to differentiate between physical (i.e., greenspace and air pollution) and social (i.e., classmate support and SES) school characteristics, as the change in exposure to these characteristics over the years may differ across these two characteristics. The social characteristics of the school are measured within the school itself. It can be expected that the exposure to these school characteristics remained stable over time, as there were hardly any changes in the number of hours of education as mandated by compulsory education within our study period. Based on that, we expected that the associations between the social characteristics of the school and adolescent mental health problems remained stable over time. Concerning the physical characteristics (i.e., air pollution and greenspace), these characteristics reflect the surroundings of schools. In contrast to the social characteristics, we assumed that adolescents in general voluntarily spend time surrounding the schools. A similar line of reasoning as for the neighbourhood effects may be applicable here, as adolescents spend more time on their screens, they may to a lesser extent roam around their schools (Oswald et al., 2020), and therefore less exposed to the physical characteristics of the school. Hence, we expected that the associations between the physical characteristics of the school and adolescent mental health problems became weaker over time.

1.2. Changes in associations between neighbourhood characteristics and adolescent mental health problems over time may depend upon the educational type

When analysing time trends in the associations between

neighbourhood and school characteristics and adolescent mental health problems, it is essential to distinguish between educational types (i.e., primary and secondary education). That is, the extent to which the associations between neighbourhood characteristics and adolescent mental health problems have declined, may vary across students who are enrolled in primary and secondary education. The Dutch educational system is characterized by an early transition from primary to secondary school at the age of 12. According to Browning et al. (2021), students attending schools in their neighbourhood are more likely to spend more time in their own neighbourhood. As most Dutch primary schools are located within the residential neighbourhood, while secondary schools are not (Van Goeverden and De Boer, 2013), students attending primary school likely spend more time in their neighbourhood than those in secondary education (Remmers et al., 2020). Moreover, in secondary education, students have more homework than in primary education, providing the latter more possibilities to spend time in their neighbourhoods (Kaal, 2022). As secondary school students generally spend less time in their neighbourhoods than primary school students, associations between neighbourhood characteristics and adolescent mental health problems may generally be weaker for secondary than primary school students. Subsequently, decreases in neighbourhood associations as a consequence of the above societal changes may be more pronounced for primary than for secondary school students.

1.3. Present study

This paper examined time trends in the associations between physical (i.e., air pollution and greenspace) and social (i.e., SES and social fragmentation/classmate support) neighbourhood and school characteristics and different indicators of adolescent mental health problems (emotional symptoms, conduct problems, peer relationship problems and hyperactivity-inattention problems). We used Dutch nationally representative, repeated cross-sectional data from 2005 to 2017 among adolescents aged 11 through 16 years enrolled in primary and secondary education to test the following hypotheses. First, we expected decreases in the associations between neighbourhood characteristics and adolescent mental health problems in this period. For the school context, we expected a decline in the associations between physical school characteristics and adolescent mental health problems, while stable associations for the social characteristics of the school. Between school characteristics and adolescent mental health problems. Second, we expected a more substantial decrease of the neighbourhood associations for primary versus secondary school students.

2. Material and methods

2.1. Study population

Data were obtained from the Dutch Health Behaviour in School-aged Children (HBSC) study, a quadrennial repeated cross-sectional survey. Nationally representative samples were collected in 2005, 2009, 2013, and 2017 and included 11- to 16-year-old adolescents attending either the last grade of primary schools (PS) or the first four grades of secondary schools (SS). Across years, identical survey procedures were employed to guarantee data comparability of the data over time. First, a random sample of schools throughout the Netherlands was drawn stratified on urbanization level. Second, one last-grade class from each primary school was randomly selected. Also, each participating secondary school provided a list of all classes, and, depending on school size, 3–5 classes were selected randomly. The response rate of schools ranged from 37% (2013/2017) to 48% (2009). The response rates among adolescents were above 92% in all years. Ethical approval for the HBSC study was obtained from the Ethics Assessment Committee of the Faculty of Social Sciences at Utrecht University (FETC17-079).

Due to missing data, 6.87% of the cases were excluded resulting in a total of 26,649 respondents included in one of the four waves. Sample

sizes were comparable over the years (2005: $n_{ps} = 1516$; $n_{ss} = 4,948$, 2009: $n_{ps} = 1647$; $n_{ss} = 5,200$, 2013: $n_{ps} = 1417$; $n_{ss} = 4,904$, 2017: $n_{ps} = 1291$; $n_{ss} = 5726$). The total number of neighbourhoods ranged from 1118 in 2005 to 1334 in 2017. For primary school students, the average number of participants per neighbourhood per survey year was 6.10, while for secondary school students, it was 4.49. The number of primary schools ranged from 68 in 2017 to 76 in 2009, while the number of secondary schools ranged from 64 in 2005 and 2013 to 74 in 2017. Similarly, the average number of participants per school per survey year was 19.17 for primary education and 73.26 for secondary education. Among primary school students, the average age was 11.23 (standard deviation (SD) = .421), and among secondary school students, the average age was 13.81 (SD = 1.250). The sample of secondary school students consisted of slightly more girls (51.4%) than the sample of primary school students (51.1%).

We tested whether the samples differed in individual-level variables across waves. For students in primary education, the sample varied significantly over time in family SES ($b = .192, p < .001$) and age ($b = -.022, p < .001$). For students in secondary education, over time differences in family SES ($b = .251, p < .001$), age ($b = -.038, p < .001$), family structure ($b = -.012, p < .001$) and educational levels ($\chi^2(9) = 268.148, p < .001$) were found. However, these differences in mean scores across waves were all negligible in size (Tables 1 and 2).

2.2. Measures

2.2.1. Adolescent mental health problems

Mental health problems were assessed through the revised version of the Strength and Difficulties Questionnaire (SDQ-R) (Duijnhof et al., 2020a). The SDQ-R showed better psychometric properties than the original SDQ for the 2017 Dutch HBSC sample (Duijnhof et al., 2020b). In the SDQ-R, the reverse-worded items of the original SDQ were excluded. The SDQ-R covered 15 items about adolescent behaviours and emotions in the past six months (e.g., “I worry a lot”, “I am restless, I cannot stay still for long”). Each item was assessed on a three-point Likert scale ranging from “not true” (0) to “certainly true” (2). The SDQ-R consisted of four subscales: emotional symptoms (5 items), hyperactivity-inattention problems (3 items), conduct problems (4

items), and peer relationship problems (3 items). Items were averaged and higher (mean) values for each subscale referred to more mental health problems. Respondents were included for each subscale if at least half of the items were completed. The subscale peer relationship problems in 2005 had the most missing values (4.88%).

2.2.2. Neighbourhood-level variables

We enriched the HBSC data with the respondent’s 4-digit postal code area.

Neighbourhood greenspace was assessed using the normalized difference vegetation index (NDVI) (Tucker, 1979) for the corresponding survey years. Landsat-8 satellite imagery between May and September with a 30 m spatial resolution were obtained through Google Earth Engine. The NDVI ranged from -1 to +1. To avoid distortions (Helbich, 2019), negative NDVI scores referring to non-vegetated soil or water were omitted before computing mean NDVI scores per 4-digit postal code. Higher scores indicated more greenspace in the neighbourhood.

Neighbourhood air pollution was measured using the annual average concentrations of fine particulate matter with diameters <2.5 µm (PM_{2.5}) (µg/m³) for the corresponding survey years. Air pollution data with a spatial resolution of approximately 1 km were derived from remote sensing data and calibrated with ground-based monitoring data (Hammer et al., 2020). PM_{2.5} concentrations were averaged per 4-digit postal code, with higher scores denoting to more air pollution in the neighbourhood.

Neighbourhood social fragmentation was captured through a composite measure representing community integration and neighbourhood connectedness (Roberts et al., 2020). We summed the z-scores of the percentage of adult residents above 18 years who were unmarried, who lived in a single-person household, and who moved to the address within the past 12 months. The index was computed based on population-wide register data aggregated per 4-digit postal code for each survey year. Higher scores denoted higher levels of social fragmentation in the area.

Neighbourhood socioeconomic status (SES) was operationalized by means of a composite measure based on register data aggregated per 4-digit postal code for each survey year. It was constructed by summing the z-scores of the area-level unemployment rate, the standardized median household income (reverse coded), and the share of households

Table 1

Descriptive statistics of the study variables among students attending primary school between 2005 and 2017 ($N_{individuals} = 5,871$, $N_{neighbourhoods} = 892$, $N_{schools} = 293$).

Variables	Range	M/% (SD)	M/% (SD)	M/% (SD)	M/% (SD)	M/% (SD)
		2005	2009	2013	2017	Overall
		N = 1516	N = 1647	N = 1417	N = 1291	N = 5871
Outcome variable						
Emotional symptoms	0–2	.44 (.40)	.41 (.40)	.46 (.41)	.41 (.39)	.43 (.43)
Conduct problems	0–2	.29 (.34)	.29 (.34)	.25 (.33)	.23 (.31)	.26 (.26)
Peer relationship problems	0–2	.37 (.40)	.36 (.41)	.37 (.40)	.36 (.38)	.37 (.37)
Hyperactivity-inattention problems	0–2	.67 (.55)	.69 (.56)	.77 (.59)	.81 (.59)	.73 (.57)
Individual-level variables						
Family SES	0–9	6.10 (1.68)	6.55 (1.60)	6.49 (1.64)	6.76 (1.54)	6.46 (1.63)
Age	11–12	11.25 (.43)	11.25 (.44)	11.23 (.42)	11.18 (.38)	11.23 (.42)
Gender ^a	0–1	51.2%	52.2%	50.0%	51.1%	51.1%
Family structure ^b	0–1	80.1%	79.2%	76.9%	80.0%	79.0%
Classmate support	1–5	4.16 (.64)	4.18 (.66)	4.23 (.65)	4.17 (.64)	4.18 (.65)
Neighbourhood-level variables						
Air pollution	7–19	13.17 (1.40)	15.59 (1.98)	12.54 (1.84)	12.01 (1.67)	13.46 (2.22)
Greenspace	0–1	.45 (.11)	.42 (.12)	.45 (.12)	.46 (.11)	.44 (.12)
Social fragmentation	-16–4	-.64 (2.26)	-.99 (2.74)	-.61 (2.26)	-.11 (2.00)	-.63 (2.37)
SES	-11–12	-.30 (2.65)	-.07 (2.39)	-.69 (2.78)	-.42 (2.43)	-.36 (2.58)
School-level variables						
Air pollution	7–19	13.02 (1.38)	14.97 (1.94)	12.23 (1.91)	12.08 (1.51)	13.10 (2.04)
Greenspace	0–1	.47 (.09)	.45 (.12)	.46 (.13)	.46 (.11)	.46 (.11)
Classmate support	1–5	4.13 (.24)	4.19 (.23)	4.23 (.21)	4.16 (.23)	4.18 (.23)
SES	0–9	6.06 (.74)	6.52 (.69)	6.42 (.63)	6.78 (.51)	6.43 (.70)

Note: variables are uncentered; significant differences across waves are discussed in text.

^a Reference category = boys.

^b Reference category = not living together with both parents.

Table 2

Descriptive statistics of the study variables among students attending secondary school between 2005 and 2017 (N_{individuals} = 20,778, N_{neighbourhoods} = 4,028, N_{schools} = 270).

	Range	M/% (SD)	M/% (SD)	M/% (SD)	M/% (SD)	M/% (SD)
		2005	2009	2013	2017	Overall
		N = 4948	N = 5200	N = 4904	N = 5726	N = 20,778
Outcome variable						
Emotional symptoms	0–2	.44 (.42)	.45 (.42)	.53 (.46)	.50 (.46)	.48 (.44)
Conduct problems	0–2	.25 (.33)	.22 (.32)	.23 (.32)	.23 (.33)	.23 (.33)
Peer relationship problems	0–2	.34 (.38)	.33 (.39)	.36 (.40)	.37 (.41)	.35 (.40)
Hyperactivity-inattention problems	0–2	.71 (.56)	.78 (.58)	.82 (.61)	.83 (.60)	.79 (.59)
Individual-level variables						
Family SES	0–9	6.00 (1.73)	6.59 (1.60)	6.56 (1.56)	6.85 (1.58)	6.51 (1.65)
Age	12–16	13.85 (1.25)	13.83 (1.25)	13.82 (1.25)	13.73 (1.26)	13.81 (1.25)
Gender ^a	0–1	50.6%	51.6%	51.5%	51.8%	51.4%
Family structure ^b	0–1	78.4%	80.4%	73.9%	76.3%	77.3%
Classmate support	1–5	4.05 (.64)	4.06 (.64)	4.10 (.65)	4.03 (.72)	4.06 (.67)
Educational level						
Low	0–1	25.2%	17.8%	23.3%	17.7%	20.8%
Lower intermediate	0–1	31.4%	35.6%	27.0%	32.8%	31.8%
Upper intermediate	0–1	24.4%	22.9%	26.8%	22.9%	24.2%
High	0–1	18.5%	23.8%	22.9%	26.6%	23.1%
Neighbourhood-level variables						
Air pollution	7–19	13.07 (1.52)	14.60 (2.48)	11.71 (2.20)	12.08 (1.51)	12.81 (2.28)
Greenspace	0–1	.47 (.11)	.46 (.12)	.48 (.13)	.47 (.12)	.47 (.12)
Social fragmentation	–18–6	–.25 (2.19)	–.42 (2.69)	–.24 (2.21)	–.29 (2.38)	–.30 (2.38)
SES	–18–7	–.33 (2.52)	–.18 (2.20)	–.36 (2.44)	–.35 (2.53)	–.31 (2.43)
Range		M/% (SD)	M/% (SD)	M/% (SD)	M/% (SD)	M/% (SD)
		2005	2009	2013	2017	Overall
School-level variables						
Air pollution	7–19	13.20 (1.52)	15.08 (2.22)	12.41 (1.92)	12.21 (1.69)	13.21 (2.17)
Greenspace	0–1	.45 (.10)	.44 (.10)	.45 (.10)	.45 (.10)	.45 (.10)
Classmate support	1–5	4.03 (.13)	4.05 (.13)	4.08 (.14)	4.01 (.15)	4.04 (.14)
SES	0–9	5.93 (.72)	6.45 (.62)	6.44 (.51)	6.77 (.59)	6.41 (.68)

Note: variables are uncentered; significant differences across waves are discussed in text.

^a Reference category = boys.

^b Reference category = not living together with both parents.

with a standardized income below the poverty line. We reverse coded this composite measure with higher scores referring to higher neighbourhood-level SES.

2.2.3. School-level variables

School greenspace and school air pollution were assessed based on the 4-digit postal code of the school using the NDVI and PM_{2.5} data as above. Again, the mean NDVI and PM_{2.5} were determined for each 4-digit postal code of the school.

School classmate support was measured by aggregating individual-level responses on three items assessing classmate support (e.g., “Most of the students in my class are kind and helpful”) using a five-point Likert scale (1 = totally agree to 5 = totally disagree) (Torsheim et al., 2000). Items were reverse coded and summed with higher scores indicating higher levels of classmate support at the school level.

School socioeconomic status (SES) was assessed by the Family Affluence Scale (FAS) (Currie et al., 2014). FAS consists of four items reflecting family material assets (e.g., “Does your family has a car”). The items were summed and aggregated to the school level with higher scores indicating a higher school-level SES.

2.2.4. Control variables

We controlled for age (in years), gender (0 = boy, 1 = girl), and family structure (i.e., whether (1) or not (0) the adolescent lives together with both parents in the primary household). To disentangle individual-level effects from school-level effects, we further controlled for classmate support and family SES at the individual level (see above for the description of these variables). In our analyses for secondary education, we included educational level the adolescent was enrolled in. Reflecting the Dutch educational system for secondary schools, we dummy-coded

these levels into four categories using ‘high’ as the reference category (1 = low; 2 = lower intermediate; 3 = upper intermediate; 4 = high). Finally, we treated time as a continuous variable.

2.3. Statistical analysis

We first performed bivariate analyses between the predictors and the indicators of adolescent mental health problems using spearman correlations. Given the categorical nature of the educational level variable in the sample of secondary school students, we conducted an one-way ANOVA instead of a spearman correlation for this variable. To take into account the different levels in our data, we performed separate bivariate analyses at the individual, neighbourhood and school level.

Next, due to the cross-nested data structure, we tested the associations between our contextual (i.e., neighbourhood and school) characteristics and adolescent mental health problems using cross-classified multilevel models (CCMM) (Barker et al., 2020; Hox et al., 2017). CCMMs consider that students attending the same school may reside in different neighbourhoods and students living in the same neighbourhood may attend different schools. Three CCMM’s containing both the neighbourhood and school level were fitted per mental health outcome. The analyses were conducted in R 4.3 (R Core Team, 2020) using the “R2MLwiN” package (Zhang et al., 2016).

To investigate the intraclass correlation coefficients (ICCs), we fitted a null model (i.e., model without any variables). Model 1 included the control variables, the survey year (i.e., time) and the neighbourhood and school level covariates. To test whether the associations changed over time, we added cross-level interactions between time and neighbourhood- and school-level variables in Model 2. It is important to include both neighbourhood- and school-level variables and cross-level

Table 3

Models 0 for each mental health outcome per educational type ($N_{\text{individuals}} = 26,649$, $N_{\text{neighbourhoods}} = 4,920$, $N_{\text{schools}} = 563$).

Outcome	Primary education				Secondary education			
	ES ^a	HIP ^b	CP ^c	PRP ^d	ES ^a	HIP ^b	CP ^c	PRP ^d
Fixed effects estimates								
Intercept	.430 (.006)	.728 (.010)	.257 (.005)	.366 (.007)	.481 (.005)	.791 (.008)	.242 (.005)	.357 (.005)
Random effect estimates								
Neighbourhood	.004 (.052)	.009 (.000)	.003 (.014)	.005 (.021)	.003 (.024)	.007 (.061)	.001 (.032)	.003 (.043)
School	.002 (.041)	.013 (.115)	.003 (.053)	.005 (.070)	.004 (.064)	.015 (.106)	.006 (.068)	.006 (.069)
Individual	.156 (.003)	.314 (.561)	.103 (.320)	.153 (.391)	.192 (.438)	.333 (.578)	.100 (.317)	.152 (.390)
Intraclass correlation Coefficients								
Neighbourhood	2.6%	2.6%	2.9%	3.4%	1.6%	2.0%	.6%	2.2%
School	1.7%	4.0%	2.5%	2.9%	2.0%	4.2%	5.7%	4.0%

Note: these models only contained the neighbourhood and school level without independent variables; standard errors are provided between brackets.

^a ES - Emotional symptoms.

^b HIP - Hyperactivity-inattention problems.

^c CP - Conduct problems.

^d PRP - Peer relationship problems.

interactions simultaneously to the model, to rule out potential confounding effects (Jennings and Bamkole, 2019). The neighbourhood-level, school-level, and time variables were grand-mean-centered allowing to compare associations over time. To compare the main effects of school-level and neighbourhood-level variables, Cohen's *d* effect sizes were computed for the variables of interest, whereby 0.1 denoted a small, 0.3 a moderate, and 0.5 a large effect (Cohen, 1988). We checked for multicollinearity among the variables using variance inflation factors (VIF), with VIF values greater than 10 indicating severe multicollinearity (Hair et al., 2006). Analyses were performed separately for primary and secondary schools to assess education-dependent associations.

3. Results

Descriptive statistics for the variables are displayed in Table 1 for primary education students and in Table 2 for secondary education students. Correlations for primary education are provided in Table S1, and for secondary education the correlations and ANOVA are shown in Table S2 and S3.

3.1. Primary education

Table 3 shows the ICCs at the neighbourhood and school level per mental health outcome for primary school students. The results indicated that for emotional symptoms, conduct problems and peer relationship problems the ICC values at the neighbourhood level were somewhat larger than the school-level ICC's, implying that there was a

Table 4

Results of CCMMs for four mental health outcomes among students attending primary schools ($N_{\text{individuals}} = 5,871$, $N_{\text{neighbourhoods}} = 892$, $N_{\text{schools}} = 293$).

Outcome	Emotional symptoms		Hyperactivity-inattention problems		Conduct problems		Peer relationship problems	
	M1	M2	M1	M2	M1	M2	M1	M2
Fixed effects								
Intercept	Estimate (S.E.)	Estimate (S.E.)	Estimate (S.E.)	Estimate (S.E.)	Estimate (S.E.)	Estimate (S.E.)	Estimate (S.E.)	Estimate (S.E.)
	.912 (.117)***	.906 (.117)***	.803 (.172)**	.906 (.117)**	.470 (.095)***	.476 (.095)***	1.005 (.116)***	1.001 (.116)***
Individual-level variables								
Family SES	-.005 (.003)	-.005 (.003)	.004 (.005)	.005 (.003)	.001 (.003)	.001 (.003)	-.009 (.003)*	-.009 (.003)*
Age	.015 (.010)	.015 (.010)	.043 (.014)**	.015 (.010)**	.029 (.008)***	.028 (.008)***	.019 (.010)*	.020 (.010)*
Gender ^a	.155 (.010)***	.155 (.010)***	-.068 (.014)***	-.070 (.010)***	-.101 (.008)***	-.101 (.008)***	-.039 (.010)***	-.039 (.010)***
Family structure ^b	-.066 (.012)***	-.066 (.012)***	-.056 (.018)**	-.066 (.012)**	-.044 (.010)***	-.044 (.010)***	-.029 (.012)*	-.029 (.012)*
Classmate support	-.156 (.008)***	-.156 (.008)***	-.118 (.012)***	-.156 (.008)***	-.109 (.006)***	-.109 (.006)***	-.179 (.008)***	-.179 (.008)***
Time	-.002 (.006)	-.009 (.007)	.046 (.009)***	-.009 (.007)*	-.011 (.005)*	-.007 (.005)	-.006 (.006)	-.010 (.007)
Neighbourhood-level variables								
Air pollution	.018 (.012)	.018 (.012)	.008 (.018)	.018 (.012)	.006 (.010)	.006 (.010)	-.006 (.012)	-.006 (.012)
Greenspace	-.098 (.109)	-.104 (.110)	-.055 (.160)	-.104 (.110)	-.039 (.086)	-.048 (.087)	-.009 (.106)	-.013 (.107)
Social fragmentation	.004 (.004)	.004 (.004)	.010 (.006)*	.004 (.004)	.001 (.003)	.002 (.003)	.010 (.004)**	.010 (.004)**
SES	-.004 (.003)	-.004 (.003)	-.002 (.005)	-.004 (.003)	-.010 (.002)***	-.010 (.003)***	-.020 (.003)***	-.020 (.003)***
School-level variables								
Air pollution	-.020 (.013)	-.019 (.013)	-.014 (.019)	-.019 (.013)	-.007 (.010)	-.007 (.010)	.005 (.012)	.006 (.012)
Greenspace	-.037 (.112)	.062 (.112)	-.010 (.168)	.062 (.112)	.038 (.089)	.050 (.089)	-.039 (.109)	-.025 (.110)
Classmate support	.024 (.028)	.028 (.029)	-.064 (.042)	.028 (.029)	-.031 (.021)	-.039 (.022)	-.035 (.026)	-.034 (.027)
SES	-.001 (.011)	-.000 (.012)	.007 (.016)	-.000 (.012)	-.026 (.008)**	-.027 (.009)**	.010 (.010)	.011 (.011)
Neighbourhood interactions								
Air pollution*time		.019 (.012)		.019 (.012)		.003 (.010)		.018 (.012)
Greenspace*time		-.143 (.110)		-.143 (.110)		-.073 (.087)		-.018 (.107)
Social fragmentation*time		-.004 (.004)		-.004 (.004)		-.002 (.003)		-.002 (.004)
SES*time		.000 (.003)		.000 (.003)		-.000 (.002)		.001 (.003)

bit more between-level variance for these three mental health outcomes at the neighbourhood level than at the school level. For hyperactivity-inattention problems, we observed the opposite.

Table 4 shows the results of Model 1 and 2 for primary school students. At the individual level, higher levels of family SES were related to less peer relationship problems. Older adolescents reported more hyperactivity-inattention problems, conduct problems and peer relationship problems. While girls reported more emotional symptoms, boys showed higher scores on the other three mental health outcomes than girls. Adolescents not growing up with both parents in the primary household or receiving little classmate support, showed higher scores on all four mental health outcomes. In addition, hyperactivity-inattention problems increased over time, while conduct problems decreased over time.

The different Models 1 for the four mental health outcomes also

showed that more neighbourhood social fragmentation was related to more hyperactivity-inattention problems and more peer relationship problems. Both effect sizes were small ($d_{HIP} = -0.13$; $d_{PRP} = -0.23$). Higher neighbourhood SES was associated with fewer conduct problems and fewer peer relationship problems; effects were of moderate size ($d_{CP} = -0.30$; $d_{PRP} = -0.49$). At the school level, only school SES was negatively related to conduct problems; this effect size was small ($d_{CP} = -0.26$).

None of the interactions between time and either neighbourhood or school characteristics were significant (Models 2). This indicates that for primary education, the associations between neighbourhood and school characteristics were stable over time.

Table 5

Results of CCMs for four mental health outcomes among students attending secondary schools ($N_{individuals} = 20,778$, $N_{neighbourhoods} = 4,028$, $N_{schools} = 270$).

Outcome	Emotional symptoms		Hyperactivity-inattention problems		Conduct problems		Peer relationship problems	
	M1	M2	M1	M2	M1	M2	M1	M2
Fixed effects	Estimate (S.E.)	Estimate (S.E.)	Estimate (S.E.)	Estimate (S.E.)	Estimate (S.E.)	Estimate (S.E.)	Estimate (S.E.)	Estimate (S.E.)
Intercept	.767 (.037)***	.771 (.037)***	.714 (.052)***	.714 (.053)***	.566 (.028)***	.569 (.028)***	.858 (.034)***	.862 (.034)***
Individual-level variables								
Family SES	-.013 (.002)***	-.013 (.002)***	.018 (.003)***	.018 (.003)***	.001 (.001)	.001 (.001)	-.014 (.002)***	-.014 (.002)***
Age	.016 (.002)***	.016 (.002)***	.012 (.003)***	.012 (.003)***	-.005 (.001)*	-.005 (.001)***	.011 (.002)***	.011 (.002)***
Gender ^a	.280 (.006)***	.280 (.006)***	-.009 (.008)	-.009 (.008)	-.080 (.004)***	-.080 (.004)***	-.028 (.005)***	-.028 (.005)***
Family structure ^b	-.061 (.007)***	-.061 (.007)***	-.086 (.009)***	-.086 (.009)***	-.051 (.005)***	-.051 (.005)***	-.031 (.006)***	-.031 (.006)***
Classmate support	-.127 (.004)***	-.127 (.004)***	-.070 (.006)***	-.070 (.006)***	-.064 (.003)***	-.064 (.003)***	-.143 (.004)***	-.143 (.004)***
Educational level ^c								
Low	.025 (.012)	.023 (.012)	.238 (.017)***	.238 (.017)***	.156 (.009)***	.155 (.009)***	.098 (.011)***	.099 (.011)***
Lower intermediate	-.005 (.010)	-.006 (.010)	.193 (.014)***	.194 (.014)***	.096 (.007)***	.096 (.008)***	.057 (.009)***	.057 (.009)***
Upper intermediate	.005 (.009)	.004 (.009)	.118 (.012)***	.118 (.012)***	.043 (.006)***	.042 (.007)***	.027 (.008)**	.026 (.008)**
Time	.016 (.004)***	.017 (.004)	.017 (.006)***	.015 (.006)*	-.001 (.003)	-.000 (.003)	.022 (.003)***	.022 (.004)***
Neighbourhood-level variables								
Air pollution	-.001 (.004)	.000 (.004)	-.003 (.005)	-.003 (.005)	-.001 (.003)	-.001 (.003)	.005 (.003)	.006 (.003)
Greenspace	-.038 (.032)	-.029 (.036)	-.032 (.047)	-.034 (.052)	-.026 (.025)	-.029 (.027)	-.005 (.030)	-.001 (.033)
Social fragmentation	.002 (.002)	.002 (.002)	.000 (.003)	.000 (.003)	-.002 (.001)	.002 (.001)	.003 (.002)	.003 (.002)
SES	.000 (.002)	-.000 (.002)	.005 (.002)*	.005 (.002)*	-.003 (.001)**	-.003 (.001)**	-.008 (.002)***	-.008 (.002)***
School-level variables								
Air pollution	-.005 (.004)	-.007 (.004)	-.001 (.006)	-.001 (.006)	.002 (.003)	.002 (.003)	-.002 (.003)	-.003 (.004)
Greenspace	-.029 (.048)	-.059 (.051)	.142 (.069)	.136 (.075)	.028 (.035)	.024 (.038)	-.040 (.040)	-.065 (.043)
Classmate support	-.017 (.029)	.014 (.030)	-.030 (.042)	-.027 (.043)	-.040 (.022)	-.044 (.022)*	-.006 (.025)	-.006 (.025)
SES	.035 (.008)***	.035 (.008)***	.066 (.011)***	.069 (.012)***	-.006 (.006)	-.006 (.006)	-.041 (.018)*	-.011 (.007)
Outcome	Emotional symptoms		Hyperactivity-inattention problems		Conduct problems		Peer relationship problems	
	M1	M2	M1	M2	M1	M2	M1	M2
Neighbourhood interactions	Estimate (S.E.)	Estimate (S.E.)	Estimate (S.E.)	Estimate (S.E.)	Estimate (S.E.)	Estimate (S.E.)	Estimate (S.E.)	Estimate (S.E.)
Air pollution*time		-.004 (.004)		.004 (.005)		.004 (.003)		.002 (.003)
Greenspace*time		-.022 (.033)		-.007 (.048)		-.009 (.025)		-.012 (.030)
Social fragmentation*time		-.004 (.002)*		-.000 (.003)		-.002 (.001)		-.002 (.002)
SES*time		-.002 (.001)		-.001 (.002)		-.000 (.001)		-.002 (.001)
School interactions								
Air pollution*time		.006 (.004)		-.004 (.006)		-.002 (.003)		.003 (.003)
Greenspace*time		.030 (.043)		.052 (.063)		.006 (.032)		.039 (.037)
Classmate support*time		.031 (.025)		-.020 (.036)		.026 (.018)		.008 (.021)
SES*time		-.005 (.005)		.004 (.008)		-.003 (.004)		.000 (.005)
Model fit								
AIC	21679	21672	36106	36101	10484	10478	18556	18549
Deviance	21873	21949	36288	36358	10689	10769	18754	18831

*p < .05, **p < .01, ***p < .001.

Note.

^a Reference category = boys.

^b Reference category = not living together with both parents.

^c Reference category = high educational level.

3.2. Secondary education

The ICCs at the neighbourhood and school level per mental health outcome for secondary school students are reported in Table 3. For each mental health outcome, considerably more between-level variance was located at the school level than at the neighbourhood level.

Table 5 shows the results of Models 1 and 2 for secondary school students. At the individual level, lower levels of family SES were related to more emotional symptoms, more peer relationship problems and less hyperactivity-inattention problems. Age was negatively related to conduct problems, while it was positively related to the other three outcomes. Girls reported more emotional symptoms, whereas boys scored higher on the other three outcomes. For all indicators of mental health problems, adolescents not living together with both parents in the primary household or those who received lower levels of classmate support reported higher levels of these problems than adolescents living with both parents or receiving higher levels of classmate support. Adolescents enrolled in the highest educational level reported less hyperactivity-inattention problems, conduct problems, and peer relationship problems compared to adolescents enrolled in the other three educational levels. Emotional symptoms, hyperactivity-inattention problems, and peer relationship problems among secondary school students increased over time, while the level of conduct problems remained stable between 2005 and 2017.

Neighbourhood SES was significantly related to mental health problems. Adolescents residing in higher SES neighbourhoods reported more hyperactivity-inattention problems, fewer conduct problems, and fewer peer relationships. For all three associations, the effect sizes were small ($d_{HIP} = 0.09$; $d_{CP} = -0.13$; $d_{PRP} = -0.25$). Concerning the school characteristics, higher levels of school SES were related to more emotional symptoms and more hyperactivity-inattention problems; both had medium effect sizes ($d_{ES} = 0.43$; $d_{HIP} = 0.45$). In contrast, school SES was negatively related to peer relationship problems, with a small effect size ($d_{PRP} = -0.21$).

The different Models 2 revealed one significant cross-level interaction out of thirty-two interactions tested. We observed a significant cross-level interaction between neighbourhood social fragmentation and time for emotional symptoms, with a small effect size ($d_{ES} = -.04$). The interaction showed that the association between neighbourhood social fragmentation and emotional symptoms shifted in direction ranging from +0.002 to -0.010.¹

3.3. Sensitivity analysis

The variance inflation factor (VIF) scores (Table S4) indicated some possible multicollinearity between school-level air pollution (VIF = 16.52) and neighbourhood air pollution (VIF = 16.44) among the primary school students. In our robustness tests, we refitted Model 1 for all four mental health outcomes for primary education by excluding either neighbourhood-level or school-level air pollution to investigate whether the effect sizes changed (Table S5). We obtained similar results. In line with the analyses conducted for secondary education, we reported models including both air pollution variables.

4. Discussion

4.1. Stable associations for neighbourhood and school characteristics and adolescent mental health problems

The aim of this study was to investigate time trends in the associations between physical and social neighbourhood and school

¹ The expected effect of neighbourhood social fragmentation on emotional symptoms: $0.002 - 0.004 * \text{survey year}$ E.g. the expected effect of neighbourhood social fragmentation in 2017 (survey year = 3): $0.002 - 0.004 * 3 = -.010$.

characteristics and adolescent mental health problems. We expected the associations between neighbourhood characteristics and adolescent mental health problems to weaken over time, whereas the associations with school characteristics to remain stable. In contrast, our results are indicative of temporally stable associations between both neighbourhood and school characteristics and adolescent mental health problems. Only one out of a possible sixty-four interactions between neighbourhood and school characteristics and adolescent mental health problems varied significantly over time. This significant interaction should not be overinterpreted, as this result is even smaller than the what is expected based on chance when applying *p-value* of 0.05 (Gravetter et al., 2020). Moreover, the interaction showed a small effect size, implying that even if the interaction warrants interpretation, changes in the associations over time were rather modest. For the school characteristics, our results were in line with our hypothesis. A possible explanation for the stable associations between school characteristics and mental health problems can be found in the stable exposure of adolescents to the school context between 2005 and 2017. Since school regulations regarding the amount of education hours hardly changed during the last decade(s), it is not surprising that neither the exposure to the school context nor the associations between school characteristics and adolescent mental health problems changed over time.

An explanation for the stable associations between the neighbourhood characteristics and adolescent mental health problems could be that the Internet allowed adolescents to remain connected to their neighbourhood even though they were less likely to be located in their neighbourhood (Hiller and Franz, 2004; Schwartz, 2014; Wilken and Humphreys, 2021). Adolescents may use the Internet to stay informed about what happens in their neighbourhood, or to stay in contact with friends and family members in their neighbourhood. For instance, Stevic et al. (2021) found that online contacts did not substitute social contacts in the neighbourhood, but rather intensified them. Assuming that these findings also apply to the Dutch context, the role of the neighbourhood in the social networks of adolescents have not lost its importance, and consequently, the neighbourhood context has remained an equally important context in the lives of adolescents. Regarding the other societal change, that is the increased level of protectiveness among parents (Brussoni et al., 2012; Lee et al., 2021; Nelson, 2010; Pain, 2006), it may be argued that this is particularly applicable to younger children (Chandio and Ali, 2019; Hancock Hoskins, 2014; Pinquart, 2017). As children grow older, they become more independent from their parents and more active in peer groups (Eamon, 2001). As a consequence, their parents may protect them to a lesser extent. Our sample consisted of children aged 11–16, meaning that they were already at the age of becoming independent of their parents. Future studies including younger children are needed to test whether this societal change may have decreased the role of the neighbourhood on child mental health problems.

4.2. Differential findings for physical and social characteristics of the neighbourhood and school

Like previous studies (Francesconi et al., 2022; Mueller et al., 2019; Reese et al., 2019; Ye et al., 2022), our findings suggest that social characteristics within the two contexts are more important than physical characteristics. First, we observed that primary school students residing in more socially fragmented neighbourhoods reported more hyperactivity-inattention problems and more peer relationship problems, which is in line with previous studies (Aminzadeh et al., 2013; Elgar et al., 2010). Socially fragmented neighbourhoods may confer lower levels of social capital (Kawachi et al., 2008), and a lack of social capital makes it harder for individuals to be more resilient in facing life adversities including mental health problems (Kawachi, 2010).

Second, neighbourhood and school SES were associated with adolescent mental health problems. Yet, the direction of these associations varied across mental health outcomes and for primary versus

secondary school students. Confirming previous studies (Dunn et al., 2015; Huang et al., 2020; Niu et al., 2019; Walsemann et al., 2009), we found that lower levels of neighbourhood SES were related to more conduct problems and more peer relationship problems among both primary and secondary school students. Also, lower levels of school SES were related to more conduct problems for primary school students and to more peer relationship problems among secondary school students. A possible explanation for these negative associations could be that adolescents in low SES neighbourhoods and/or attending low SES schools are more likely to be exposed to certain deviant behaviour, such as conduct problems and peer relationship problems (Galster, 2012). A high concentration of deviant peers may set the norm for deviant behaviour, and adolescents may tend to adhere to these norms to be accepted in the group (Dubow et al., 1997; Galster, 2012; Simons et al., 1996).

For secondary school students, we observed that higher levels of school SES were related to more emotional symptoms and more hyperactivity-inattention problems, and higher levels of neighbourhood SES were related to more hyperactivity-inattention problems. It could be that in schools and neighbourhoods where parents have a relatively high SES, a harmful environment is created for certain aspects of adolescent mental health. In these contexts, parents may have relatively high educational expectations for their children and adolescents in these contexts may frequently compare themselves with ambitious peers, which both may result in experiencing stress (De Looze et al., 2020; Luthar et al., 2020). In turn, these levels of stress may be related to more emotional problems (Aanesen et al., 2017; Eppelmann et al., 2016; Tharaldsen et al., 2022; Wiklund et al., 2012) and more hyperactivity-inattention problems (Eppelmann et al., 2016).

4.3. Differential findings for adolescents in primary and secondary education

Congruent with previous Dutch (Brons et al., 2022; Pauwels et al., 2015; Sykes and Musterd, 2011), Flemish (De Clercq et al., 2014), and US studies (Milliren et al., 2018; Richmond et al., 2016), our results indicated that for secondary school students school effects were larger than neighbourhood effects. Although the number of associations between neighbourhood and school characteristics and the mental health outcomes was the same for secondary school students, we observed bigger effect sizes for school characteristics than neighbourhood characteristics. Also, considerably more variance in mental health problems was attributed to the school level than to the neighbourhood level. For primary school students, we observed the opposite: neighbourhood effects were more sizeable than school effects. This was apparent from the number of significant associations for the neighbourhood and school characteristics and the larger effect sizes for the neighbourhood than school characteristics. Moreover, for primary school students, overall, slightly more variance was attributed to the neighbourhood level compared to the school level.

This difference between students in primary education and secondary education may be explained by a difference in exposures to these contexts between the two groups of students. It is generally known that primary school students spend more time in the neighbourhood compared to secondary school students (Kaal, 2021). As such, primary school students may be more frequently exposed to negative and positive neighbourhood characteristics than secondary school students, implying that the neighbourhood has a bigger impact on mental health problems for primary school students than secondary school students (Francesoni et al., 2022; Galster, 2012; Visser et al., 2021).

4.4. Strengths and limitations

This study has several strengths. Our analyses were based on large-scale and nationally representative data containing the same measurements across waves. Further, our models were comprehensively

adjusted across multiple contexts. Lastly, adolescent mental health problems were assessed by a validated scale based on self-reported data differentiating between several mental health indicators (Duijnhof et al., 2020a). Alongside these strengths, several limitations need to be recognised. First, the cross-sectional design of our study hinders causal inference and as a consequence our results may both include causation and selection effects. That is, characteristics of the contexts may not only influence the level of mental health problems among adolescents, but adolescents with mental health problems may also be more likely to reside in for instance disadvantaged neighbourhoods (Rolheiser et al., 2022). As there is more support for the direction that contextual characteristics impact adolescent mental health problems (Roche et al., 2022), we expect that our associations mainly reflect an effect of the neighbourhood/school on adolescent mental health problems. Also, by controlling for family structure and individual-level SES, we attempted to reduce results reflecting these selection effects. Second, despite our extensive assessment period of 2005–2017, we may not have covered a large enough period to include the societal changes that may have led to decreases in neighbourhood effects. For example, the Internet was introduced in 1991 and in 2005 already 71 percent of 12–15 years olds reported using Internet daily (CBS Statline, 2016). Third, for the social characteristics of the school, we aggregated data from a limited number of individuals. For primary schools, these data are based on one class, and for secondary schools, these data are based on three to five classes. These limited number of individual-level responses may not appropriately reflect the school environment. Yet, we overall expect these data to suffice as the classes were randomly selected at each school, making individual-level responses likely to be generalizable for the entire school.

5. Conclusions

This study examined time trends in the associations between neighbourhood and school characteristics and adolescent mental health problems between 2005 and 2017 in the Netherlands. Even though society has changed in several ways and scholars sometimes suggest that the neighbourhood plays a less important role in the lives of adolescents than two decades ago, our findings indicated that associations between both neighbourhood and school characteristics and adolescent mental health problems remained stable. Findings also showed that only social characteristics within the two contexts were associated with adolescent mental health problems. Also, for secondary school students, school effects were larger than neighbourhood effects, while the opposite was true for primary school students. Specifically, primary school students residing in more socially fragmented or lower socioeconomic status (SES) neighbourhoods, and lower SES schools, reported more conduct problems and peer relationship problems. For secondary school students, only the SES of the school and the neighbourhood was associated with all four aspects of mental health problems. For conduct problems and peer relationship problems these associations were negative, while they were positive for emotional problems and hyperactivity-inattention problems.

Our findings suggest that health interventions for students in primary education may be more effective when targeting social processes in the neighbourhood than in schools. For students in secondary education, health interventions seem most effective when targeting social processes at schools. As the context of both a low and high SES neighbourhood and school is associated with (different) mental health risks for adolescents, both types of neighbourhoods and schools may need to target the mental health of their pupils. More research is warranted that covers decades, to test whether our findings on time trends in associations between neighbourhood characteristics and adolescent mental health problems can be replicated. Also, future research may aim to explain why a high SES neighbourhood and school context may both entail elements of risk and resilience in its pupils and why neighbourhood and school effects vary strongly across primary and secondary school students.

Outcome	Emotional symptoms		Hyperactivity-inattention problems		Conduct problems		Peer relationship problems	
	M1	M2	M1	M2	M1	M2	M1	M2
School interactions	Estimate (S.E.)	Estimate (S.E.)	Estimate (S.E.)	Estimate (S.E.)	Estimate (S.E.)	Estimate (S.E.)	Estimate (S.E.)	Estimate (S.E.)
Air pollution*time	-.022 (.012)			-.022 (.012)		.001 (.010)		-.020 (.012)
Greenspace*time		-.026 (.114)		-.026 (.114)		.025 (.090)		-.054 (.111)
Classmate support*time		.033 (.023)		.033 (.023)		-.029 (.018)		.012 (.022)
SES*time		.005 (.009)		.005 (.009)		.004 (.007)		.002 (.009)
Model fit								
AIC	5236	5217	9844	9829	2860	2852	5173	5166
Deviance	5382	5435	9978	10027	3013	3081	5321	5386

*p < .05, **p < .01, ***p < .001.

Note.

^a Reference category = boys.

^b Reference category = not living together with both parents.

Declarations of interest

None.

Data availability

The data that has been used is confidential.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.healthplace.2023.103140>.

References

- Aanesen, F., Meland, E., Torp, S., 2017. Gender differences in subjective health complaints in adolescence: the roles of self-esteem, stress from schoolwork and body dissatisfaction. *Scand. J. Publ. Health* 45 (4), 389–396, 1.1177/1403494817690940.
- Aldridge, J.M., McChesney, K., 2018. The relationships between school climate and adolescent mental health and wellbeing: a systematic literature review. *Int. J. Educ. Res.* 88, 121–145, 1.1016/j.ijer.2018.01.012.
- Allison, K.W., Burton, L., Marshall, S., Perez-Febles, A., Yarrington, J., Kirsh, L.B., Merriwether-DeVries, C., 1999. Life experiences among urban adolescents: examining the role of context. *Child Dev.* 70 (4), 1017–1029, 1.1111/1467-8624.00074.
- Aminzadeh, K., Denny, S., Utter, J., Milfont, T.L., Ameratunga, S., Teevale, T., Clark, T., 2013. Neighbourhood social capital and adolescent self-reported wellbeing in New Zealand: a multilevel analysis. *Soc. Sci. Med.* 84, 13–21, 1.1016/j.socscimed.2013.02.012.
- Andreotti, A., 2014. Neighborhoods in the globalized world. *Neighborhoods In The Globalized World* 7–19.
- Barker, K.M., Dunn, E.C., Richmond, T.K., Ahmed, S., Hawrilenko, M., Evans, C.R., 2020. Cross-classified multilevel models (CCMM) in health research: A systematic review of published empirical studies and recommendations for best practices. *SSM-Population Health* 12, 100661.
- Bartolini, S., Bilancini, E., Pugno, M., 2013. Did the decline in social connections depress Americans' happiness? *Soc. Indic. Res.* 110 (3), 1033–1059, 1.1007/s11205-011-9971-x.
- Boen, C.E., Kozlowski, K., Tyson, K.D., 2020. "Toxic" schools? How school exposures during adolescence influence trajectories of health through young adulthood. *SSM-population health* 11, 100623, 1.1016/j.ssmph.2021.100623.
- Brons, M.E., Bolt, G.S., Helbich, M., Visser, K., Stevens, G.W., 2022. Independent associations between residential neighbourhood and school characteristics and adolescent mental health in The Netherlands. *Health Place* 74, 102765, 1.1016/j.healthplace.2022.102765.
- Browning, C.R., Calder, C.A., Boettner, B., Tarrence, J., Khan, K., Soller, B., Ford, J.L., 2021. Neighborhoods, activity spaces, and the span of adolescent exposures. *Am. Socio. Rev.* 86 (2), 201–233, 1.1177/0003122421994219.
- Brussoni, M., Olsen, L.L., Pike, I., Sleet, D.A., 2012. Risky play and children's safety: balancing priorities for optimal child development. *Int. J. Environ. Res. Publ. Health* 9 (9), 3134–3148, 1.3390/ijerph9093134.
- Chandio, A.R., Ali, M., 2019. The role of socialization in child's personality development. *Catalyst: Research Journal of Modern Sciences* 1 (1), 66–84.
- Cohen, J., 1988. *Statistical Power Analysis for the Behavioral Sciences*, second ed. Lawrence Erlbaum Associates, Hillsdale, NJ.
- Coumans, M.H.S., Schmeets, J.J.G., 2020. 20th of August. *Sociaal contact: kwantiteit en kwaliteit*. CBS. <https://www.cbs.nl/nl-nl/longread/statistische-trends/2019/sociaal-contact-kwantiteit-en-kwaliteit?onepage=true>.
- Currie, C., Inchley, J., Molcho, M., Lenzi, M., Veselska, Z., Wild, F., 2014. *Health Behaviour in School-Aged Children (HBSC) Study Protocol: Background, Methodology and Mandatory Items for the 2013/14 Survey*.
- De Clercq, B., Pfoertner, T.K., Elgar, F.J., Hublet, A., Maes, L., 2014. Social capital and adolescent smoking in schools and communities: a cross-classified multilevel analysis. *Soc. Sci. Med.* 119, 81–87, 1.1016/j.socscimed.2014.08.018.
- De Looze, M.E., Cosma, A.P., Vollebergh, W.A., Duin Hof, E.L., de Roos, S.A., van Dorsselaer, S.A.F.M., et al., 2020. Trends over time in adolescent emotional wellbeing in The Netherlands, 2005-2017: links with perceived schoolwork pressure, parent-adolescent communication and bullying victimization. *J. Youth Adolesc.* 49 (10), 2124–2135, 1.1007/s10964-020-01280-4.
- Dubow, E.F., Edwards, S., Ippolito, M.F., 1997. Life stressors, neighborhood disadvantage, and resources: a focus on inner-city children's adjustment. *J. Clin. Child Psychol.* 26 (2), 130–144, 1.1207/s15374424jccp2602_2.
- Duin Hof, E.L., Lek, K.M., De Looze, M.E., Cosma, A., Mazur, J., Gobina, I., et al., 2020a. Revising the self-report strengths and difficulties questionnaire for cross-country comparisons of adolescent mental health problems: the SDQ- R. *Epidemiol. Psychiatr. Sci.* 29, 1.1017/S2045796019000246.
- Duin Hof, E., Smid, S.C., Vollebergh, W.A.M., Stevens, G.W.J.M., 2020b. Immigration background and adolescent mental health problems: the role of family affluence, adolescent educational level and gender. *Soc. Psychiatr. Psychiatr. Epidemiol.* 55 (4), 435–445, 1.1007/s00127-019-01821-8.
- Dunn, E.C., Richmond, T.K., Milliren, C.E., Subramanian, S.V., 2015. Using cross-classified multilevel models to disentangle school and neighborhood effects: an example focusing on smoking behaviors among adolescents in the United States. *Health Place* 31, 224–232, 1.1016/j.healthplace.2014.12.001.
- Eamon, M.K., 2001. Poverty, parenting, peer, and neighborhood influences on young adolescent antisocial behavior. *J. Soc. Serv. Res.* 28 (1), 1–23, 1.1300/J079v28n01_01.
- Elgar, F.J., Trites, S.J., Boyce, W., 2010. Social capital reduces socio-economic differences in child health: evidence from the Canadian Health Behaviour in School-Aged Children study. *Canadian Journal of Public Health/Revue Canadienne de Sante'e Publique* S23–S27, 1.1007/BF03403978.
- Eppelmann, L., Parzer, P., Lenzen, C., Bürger, A., Haffner, J., Resch, F., Kaess, M., 2016. Stress, coping and emotional and behavioral problems among German high school students. *Mental Health & Prevention* 4 (2), 81–87, 1.1016/j.mhp.2016.03.002.
- Evans, C.R., Onnela, J.P., Williams, D.R., Subramanian, S.V., 2016. Multiple contexts and adolescent body mass index: schools, neighborhoods, and social networks. *Soc. Sci. Med.* 162, 21–31, 1.1016/j.socscimed.2016.06.002.
- Forns, J., Dadvand, P., Foraster, M., Alvarez-Pedrerol, M., Rivas, I., López-Vicente, M., et al., 2016. Traffic-related air pollution, noise at school, and behavioral problems in Barcelona schoolchildren: a cross-sectional study. *Environ. Health Perspect.* 124 (4), 529–535, 1.1289/ehp.1409449.
- Francesconi, M., Flouri, E., Kirkbride, J.B., 2022. The role of the built environment in the trajectories of cognitive ability and mental health across early and middle childhood: results from a street audit tool in a general-population birth cohort. *J. Environ. Psychol.* 82, 101847, 1.1016/j.jenvp.2022.101847.
- Galster, G.C., 2012. The mechanism (s) of neighbourhood effects: theory, evidence, and policy implications. In: *Neighbourhood Effects Research: New Perspectives*. Springer, Dordrecht, pp. 23–56, 1.1007/978-94-007-2309-2.
- Gravetter, F.J., Wallnau, L.B., Forzano, L.A.B., Witnauer, J.E., 2020. *Essentials of Statistics for the Behavioral Sciences*. Cengage Learning.
- Hair, J.F., Black, W.C., Babin, B.J., Anderson, R.E., Tatham, R.L., 2006. *Multivariate Data Analysis*, vol. 6.
- Hammer, M.S., van Donkelaar, A., Li, C., Lyapustin, A., Sayer, A.M., Hsu, N.C., et al., 2020. Global estimates and long-term trends of fine particulate matter concentrations (1998–2018), 789 *Environ. Sci. Technol.* 54 (13), 7879, 1.1021/acs.est.0c1764.
- Hancock Hoskins, D., 2014. Consequences of parenting on adolescent outcomes. *Societies* 4 (3), 506–531, 1.3390/soc4030506.
- Helbich, M., 2019. Spatiotemporal contextual uncertainties in green space exposure measures: exploring a time series of the normalized difference vegetation indices. *Int. J. Environ. Res. Publ. Health* 16 (5), 852, 1.3390/ijerph16050852.
- Hiller, H.H., Franz, T.M., 2004. New ties, old ties and lost ties: the use of the internet in diaspora. *New Media Soc.* 6 (6), 731–752, 1.1177/146144804044327.
- Hox, J., Moerbeek, M., Van de Schoot, R., 2017. *Multilevel analysis: Techniques and applications*. Routledge.
- Huang, Y., Edwards, J., Laurel-Wilson, M., 2020. The shadow of context: neighborhood and school socioeconomic disadvantage, perceived social integration, and the mental

- and behavioral health of adolescents. *Health Place* 66, 102425, 1.1016/j.healthplace.2021.102425.
- Jennings, V., Bamkole, O., 2019. The relationship between social cohesion and urban green space: an avenue for health promotion. *Int. J. Environ. Res. Publ. Health* 16 (3), 452, 1.3390/ijerph16030452.
- Kaal, M., 2022. *Onderzoek Buitenspeel* 2022. Jantje Beton, Utrecht.
- Kawachi, I., 2010. The relationship between health assets, social capital and cohesive communities. In: *Health Assets in a Global Context*. Springer, New York, NY, pp. 167–179, 1.1007/978-1-4419-5921-8_9.
- Kawachi, I., Subramanian, S.V., Kim, D., 2008. Social capital and health. In: *Social Capital and Health*. Springer, New York, NY, pp. 1–26.
- Lee, E.Y., Bains, A., Hunter, S., Ament, A., Brazo-Sayavera, J., Carson, V., et al., 2021. Systematic review of the correlates of outdoor play and time among children aged 3–12 years. *Int. J. Behav. Nutr. Phys. Activ.* 18 (1), 1–46, 1.1186/s12966-021-01097-9.
- LeMoyné, T., Buchanan, T., 2011. Does “hovering” matter? Helicopter parenting and its effect on well-being. *Socio. Spectr.* 31 (4), 399–418, 1.1080/02732173.2011.574038.
- Loebach, J., Gilliland, J., 2016. Neighbourhood play on the endangered list: examining patterns in children’s local activity and mobility using GPS monitoring and qualitative GIS. *Child Geogr.* 14 (5), 573–589, 1.1080/14733285.2016.1140126.
- Luthar, S.S., Kumar, N.L., Zillmer, N., 2020. High-achieving schools connote risks for adolescents: problems documented, processes implicated, and directions for interventions. *Am. Psychol.* 75 (7), 983, 1.1037/amp.0000556.
- Mahmoudi Farahani, L., 2016. The value of the sense of community and neighbouring. *Hous. Theor. Soc.* 33 (3), 357–376, 1.1080/14036096.2016.1155480.
- Marshall, S.J., Gorely, T., Biddle, S.J., 2006. A descriptive epidemiology of screen-based media use in youth: a review and critique. *J. Adolesc.* 29 (3), 333–349, 1.1016/j.adolescence.2005.08.016.
- Milliren, C.E., Evans, C.R., Richmond, T.K., Dunn, E.C., 2018. Does an uneven sample size distribution across settings matter in cross-classified multilevel modeling? Results of a simulation study. *Health Place* 52, 121–126, 1.1016/j.healthplace.2018.05.009.
- Minh, A., Muhajarine, N., Janus, M., Brownell, M., Guhn, M., 2017. A review of neighborhood effects and early child development: how, where, and for whom, do neighborhoods matter? *Health Place* 46, 155–174, 1.1016/j.healthplace.2017.04.012.
- Mohai, P., Kweon, B.S., Lee, S., Ard, K., 2011. Air pollution around schools is linked to poorer student health and academic performance. *Health Aff.* 30 (5), 852–862, 1.1377/hlthaff.2011.0077.
- Mueller, M.A., Flouri, E., Kokosi, T., 2019. The role of the physical environment in adolescent mental health. *Health Place* 58, 102153, 1.1016/j.healthplace.2019.102153.
- Nelson, M.K., 2010. *Parenting Out of Control: Anxious Parents in Uncertain Times*. NYU Press.
- Niu, L., Hoyt, L.T., Pachucki, M.C., 2019. Context matters: adolescent neighborhood and school influences on young adult body mass index. *J. Adolesc. Health* 64 (3), 405–441, 1.1016/j.jadohealth.2018.09.024.
- Oswald, T.K., Rumbold, A.R., Kedzior, S.G., Moore, V.M., 2020. Psychological impacts of “screen time” and “green time” for children and adolescents: a systematic scoping review. *PLoS One* 15 (9), e0237725, 1.1371/journal.pone.0237725.
- Pain, R., 2006. Paranoid parenting? Rematerializing risk and fear for children. *Soc. Cult. Geogr.* 7 (2), 221–243, 1.1080/14649360600600585.
- Parsons, K.J., Traunter, J., 2020. Muddy knees and muddy needs: parents perceptions of outdoor learning. *Child Geogr.* 18 (6), 699–711, 1.1080/14733285.2019.1694637.
- Pauwels, L.J., Weerman, F.M., Bruinsma, G.J., Bernasco, W., 2015. How much variance in offending, self-control and morality can be explained by neighbourhoods and schools? An exploratory cross-classified multi-level analysis. *Eur. J. Crim. Pol. Res.* 21 (4), 523–537, 1.1007/s10610-014-9262-6.
- Pinquart, M., 2017. Associations of parenting dimensions and styles with externalizing problems of children and adolescents: an updated meta-analysis. *Dev. Psychol.* 53 (5), 873, 1.1037/dev0000295.
- Reese, G., Oettler, L.M., Katz, L.C., 2019. Imagining the loss of social and physical place characteristics reduces place attachment. *J. Environ. Psychol.* 65, 101325, 1.1016/j.jenvp.2019.101325.
- Remmers, T., Van Kann, D., Kremers, S., Ettema, D., De Vries, S.I., Vos, S., Thijs, C., 2020. Investigating longitudinal context-specific physical activity patterns in transition from primary to secondary school using accelerometers, GPS, and GIS. *Int. J. Behav. Nutr. Phys. Activ.* 17 (1), 1–14, 1.1186/s12966-020-00962-3.
- Richmond, T.K., Dunn, E.C., Milliren, C.E., Rosenfeld Evans, C., Subramanian, S.V., 2016. Disentangling overlapping influences of neighborhoods and schools on adolescent body mass index. *Obesity* 24 (12), 2570–2577, 1.1002/oby.21672.
- Roberts, H., van Lissa, C., Helbich, M., 2020. Perceived neighbourhood characteristics and depressive symptoms: potential mediators and the moderating role of employment status. *Soc. Sci. Med.* 268, 113533, 1.1016/j.socscimed.2021.113533.
- Roche, S., Spring, A., Moore, A., 2022. Childhood neighborhoods and health: census-based neighborhood measures versus residential lived experiences. *Health Place* 78, 102902, 1.1016/j.healthplace.2022.102902.
- Rolheiser, L., Zacher, M., Subramanian, S.V., Arcaya, M.C., 2022. Do health trajectories predict neighborhood outcomes? Evidence of health selection in a diverse sample of US adults. *Health Place* 73, 102713, 1.1016/j.healthplace.2021.102713.
- Schwartz, R., 2014. *Online Place Attachment*, vol. 85. *Mobility and Locative Media*.
- Simons, R.L., Johnson, C., Beaman, J., Conger, R.D., Whitbeck, L.B., 1996. Parents and peer group as mediators of the effect of community structure on adolescent problem behavior. *Am. J. Community Psychol.* 24 (1), 145–171, 1.1007/BF02511885.
- Statline, C.B.S., 2016. *ICT gebruik van personen naar persoonskenmerken, 2005–2013*. Available online: <https://opendata.cbs.nl/#/CBS/nl/dataset/71098ned/table>. (Accessed 30 January 2022).
- Statline, C.B.S., 2019. *Internet; toegang, gebruik en faciliteiten; 2012–2019*. Available online: <https://opendata.cbs.nl/statline/#/CBS/nl/dataset/83429NED/table?dl=91F4>. (Accessed 24 November 2021).
- Stevic, A., Schmuck, D., Karsay, K., Matthes, J., 2021. Are smartphones enhancing or displacing face-to-face communication with close ties? A panel study among adults. *Int. J. Commun.* 15, 27.
- Sykes, B., Musterd, S., 2011. Examining neighbourhood and school effects simultaneously: what does the Dutch evidence show? *Urban Stud.* 48 (7), 1307–1331, 1.1177/0042098010371393.
- Tharaldsen, K.B., Tvedt, M.S., Caravita, S.C.S., Bru, E., 2022. Academic stress: links with emotional problems and motivational climate among upper secondary school students. *Scand. J. Educ. Res.* 1–14, 1.1080/00313831.2022.2116480.
- Thulin, E., Vilhelmsen, B., 2019. More at home, more alone? Youth, digital media and the everyday use of time and space. *Geoforum* 100, 41–45, 1.1016/j.geoforum.2019.02.010.
- Torsheim, T., Wold, B., Samdal, O., 2000. The teacher and classmate support scale: factor structure, test-retest reliability and validity in samples of 13-and 15-year-old adolescents. *Sch. Psychol. Int.* 21 (2), 195–212, 1.1177/0143034300212006.
- Tucker, C.J., 1979. Red and photographic infrared linear combinations for monitoring vegetation. *Rem. Sens. Environ.* 8 (2), 127, 15.
- Van Goeverden, C.D., De Boer, E., 2013. School travel behaviour in The Netherlands and Flanders. *Transport Pol.* 26, 73–84, 1.1016/j.tranpol.2013.01.004.
- Van Kempen, R., Wissink, B., 2014. Between places and flows: towards a new agenda for neighbourhood research in an age of mobility. *Geogr. Ann. B Hum. Geogr.* 96 (2), 95–108, 1.1111/geob.12039.
- Vanaken, G.J., Danckaerts, M., 2018. Impact of green space exposure on children’s and adolescents’ mental health: a systematic review. *Int. J. Environ. Res. Publ. Health* 15 (12), 2668, 1.3390/ijerph15122668.
- Visser, K., Bolt, G., van Kempen, R., 2015. A good place to raise your children? The diversity of parents’ neighbourhood perceptions and parenting practices in a low-income, multi-ethnic neighbourhood: a case study in Rotterdam, 12 *Geoforum* 64, 112, 1.1016/j.geoforum.2015.06.011.
- Visser, K., Bolt, G., Finkenauer, C., Jonker, M., Weinberg, D., Stevens, G.W., 2021. Neighbourhood deprivation effects on young people’s mental health and well-being: a systematic review of the literature. *Soc. Sci. Med.* 270, 113542, 1.1016/j.socscimed.2021.113542.
- Walsemann, K.M., Gee, G.C., Geronimus, A.T., 2009. Ethnic differences in trajectories of depressive symptoms: disadvantage in family background, high school experiences, and adult characteristics. *J. Health Soc. Behav.* 50 (1), 82–98, 1.1177/002214650905000106.
- Wiklund, M., Malmgren-Olsson, E.B., Öhman, A., Bergström, E., Fjellman-Wiklund, A., 2012. Subjective health complaints in older adolescents are related to perceived stress, anxiety and gender—a cross-sectional school study in Northern Sweden. *BMC Publ. Health* 12, 1–13, 1.1186/1471-2458-12-993.
- Wilken, R., Humphreys, L., 2021. Placemaking through mobile social media platform Snapchat. *Convergence* 27 (3), 579–593, 1.1177/1354856521989518.
- Ye, T., Yu, P., Wen, B., Yang, Z., Huang, W., Guo, Y., et al., 2022. Greenspace and Health Outcomes in Children and Adolescents: A Systematic Review. *Environmental Pollution*, 120193, 1.1016/j.envpol.2022.120193.
- Zhang, Z., Parker, R.M., Charlton, C.M., Leckie, G., Browne, W.J., 2016. R2MLwiN: a package to run MLwiN from within R. *J. Stat. Software* 72, 1–43, 1.18637/jss.v072.i10.
- Zhang, Y., Mavoa, S., Zhao, J., Raphael, D., Smith, M., 2020. The association between green space and adolescents’ mental well-being: a systematic review. *Int. J. Environ. Res. Publ. Health* 17 (18), 664, 1.3390/ijerph17186640.