

Immigrant–native disparities in adolescent mental health during COVID-19 school closures: a multilevel cross-national analysis (PISA 2022)

Pedro San Martin Soares

pedrosmssoares@hotmail.com

State Health Department of Rio Grande do Sul

Research Article

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Abstract

Purpose

This study aimed to examine the associations between COVID-19-related school closures and psychosomatic symptoms and life satisfaction among 15-year-old adolescents, and to assess whether these associations differed according to immigrant background.

Methods

Public-use data from the 2022 cycle of the Programme for International Student Assessment (PISA 2022) from 13 participating countries were analysed. Associations were estimated using multilevel linear regression models adjusted for student-, school-, and country-level covariates. Mediation analyses examined loneliness during school closures, family support, and school belonging as potential mechanisms. Country-stratified analyses and a negative control analysis using school closures due to non-COVID reasons were also conducted.

Results

COVID-19-related school closures were positively associated with psychosomatic symptoms ($b = 0.117$; 95% CI: 0.102; 0.133). First-generation immigrant students reported fewer psychosomatic symptoms than native-born peers ($b = -0.048$; 95% CI: -0.077 ; -0.018), consistent with a healthy immigrant effect. Second-generation immigrant students exposed to COVID-19 school closures reported substantially lower life satisfaction than their native-born counterparts ($b = -0.084$; 95% CI: -0.133 ; -0.035). School belonging was the only significant mediating pathway, linking COVID-19 school closures to both psychosomatic symptoms and lower life satisfaction among second-generation students. Cross-national analyses revealed substantial heterogeneity across countries.

Conclusions

The findings highlight the importance of fostering school belonging and social inclusion for immigrant students during future public health emergencies.

Introduction

The COVID 19 pandemic imposed unprecedented disruptions on educational systems worldwide. By April 2020, approximately 1.6 billion learners across 190 countries had been affected by school closures mandated to contain viral transmission [1]. Although considerable attention has been devoted to the cognitive consequences of these closures, including learning loss estimated at between 0.10 and 0.20 standard deviations in mathematics globally [2, 3], the mental health toll has received comparatively less examination at the population level, particularly among socially vulnerable adolescent subgroups.

Psychosomatic symptoms, encompassing recurrent headaches, abdominal pain, sleep disturbances, depressive mood and anxiety, represent a well established indicator of psychological distress in adolescence [4]. Evidence gathered during and after the initial pandemic waves consistently documented increases in such symptoms, alongside elevated rates of anxiety and depression [3, 5]. A systematic review of 41 observational studies spanning six continents reported that higher rates of loneliness during COVID 19 were robustly associated with greater depressive symptomatology among children and adolescents, with effects persisting up to nine years later [6]. A cross national analysis comparing

pre and post pandemic surveys in Israel found that the proportion of adolescents reporting daily psychosomatic symptoms rose from 20% in 2019 to approximately 30% in 2022, a trajectory attributed in part to the sustained disruption of school based social connections [7].

Despite the expanding evidence base, most large scale studies of pandemic related adolescent mental health have conceptualised adolescents as a homogeneous group, thereby limiting attention to potential differences according to immigrant background. Immigrant adolescents, as well as second-generation youth born in the host country to immigrant parents, enter the school system with a distinct set of social exposures, including acculturative stress, language barriers, housing instability, and reduced access to culturally adapted mental health services, which may interact with pandemic related stressors in ways not captured by analyses of the general student population [8, 9].

Immigrant background and adolescent mental health

A systematic review of 51 studies published between 2013 and 2024 found overall elevated risks for psychosomatic symptoms, psychotic experiences, eating disorders, and suicidal behaviours among adolescents with a migration background in Europe [10]. In contexts of prolonged stress and social disruption, life satisfaction in adolescence, a central component of subjective well-being, has been shown to be closely linked to emotional distress and psychosomatic symptoms [11]. Multilevel analyses using the 2017 and 2018 Health Behaviour in School aged Children HBSC study, encompassing 29 European countries, demonstrated that both first and second generation immigrant adolescents reported higher levels of life dissatisfaction and psychosomatic symptoms than their native born peers, and that this association varied substantially across school and country contexts [11]. Social capital at the individual, school, and national levels partially accounted for these disparities, suggesting that social environmental conditions mediate the pathway from immigration status to mental health outcomes.

The mechanisms underlying these disparities are multifactorial. Immigrant adolescents, particularly those of the first generation, frequently face challenges in developing peer relationships due to language barriers and cultural differences, which may reduce their sense of belonging in school, itself a robust predictor of adolescent wellbeing [12]. Parental resources for educational support are also differentially distributed, with first generation immigrant families disproportionately represented in lower income occupational strata, limiting access to material conditions conducive to remote learning, such as dedicated study space, personal digital devices, and high speed internet connectivity [13]. School closures, by removing the institutional structure that partially compensates for these disadvantages, may therefore have amplified pre existing vulnerabilities.

Evidence directly comparing pandemic related mental health outcomes between immigrant and native born adolescents remains sparse and geographically circumscribed. Pieh et al. [14], in a matched pairs study of Austrian adolescents conducted after several months of remote schooling, found that students with a migration background reported poorer wellbeing and higher rates of depression and anxiety than native born peers. However, that study was conducted in a single country and relied on a convenience sample of uncertain representativeness. To date, no study has examined this question using nationally representative, cross-nationally comparable data from the post-pandemic assessment cycle.

School closure, loneliness, and the school-as-buffer hypothesis

Schools perform a multiplicity of functions beyond academic instruction, serving as primary sites of peer socialization, structured daily routine, access to nutrition, and early identification of mental health needs [3, 5]. For immigrant adolescents, school may carry additional significance as a key locus of social integration and linguistic development [15]. The school-as-social-buffer hypothesis posits that, for socially vulnerable youth, school attendance provides a

protective scaffolding that partially offsets adverse home environments; conversely, school closure removes this buffer, with consequences that may be more severe for those who depend on it most [3].

Loneliness during pandemic-related disruptions constitutes a plausible proximal pathway linking large-scale social restrictions to deteriorations in adolescent mental health. Longitudinal evidence indicates that loneliness emerged as a salient psychosocial outcome during the COVID-19 pandemic, closely tied to psychological distress among adolescents [16]. In parallel, studies examining school closures highlight the disruption of peer contact and daily social structure as key mechanisms through which educational disruptions may amplify loneliness and related psychosomatic complaints [3]. Immigrant adolescents may be especially susceptible to pandemic-induced loneliness, given that their social networks are frequently smaller, more linguistically homogeneous, and more dependent on school-based contact than those of their native-born peers [8, 17]. If school closure disproportionately disrupts the social connections of immigrant students, loneliness may partially mediate the differential impact of closures on their psychosomatic symptom profiles.

Family support represents a potentially protective counter-mechanism. However, the capacity of immigrant families to provide effective academic and emotional support during remote schooling may be constrained by language barriers, work obligations in essential or precarious employment that preclude sustained presence at home, and limited familiarity with the host country's educational system and its institutional expectations [17, 18]. During periods of school closure, these constraints may reduce parents' ability to compensate for the loss of school-based support, thereby disproportionately disadvantaging first-generation immigrant students [19]. Under such conditions, reduced familial and educational support may compound social isolation, potentially intensifying both loneliness and the associated burden of psychosomatic symptoms [8, 16].

Knowledge gaps and rationale for the present study

In this context, three specific knowledge gaps motivate the present study. First, no population-based, cross-national study has examined whether COVID-19-related school closures differentially affected psychosomatic symptoms and life satisfaction among immigrant and native-born adolescents. Second, the mechanisms through which exposure to school closures may translate into differential mental health outcomes across immigrant generations remain uncharacterised at scale. Third, although substantial cross-national heterogeneity is expected in the magnitude of immigrant–native mental health disparities, given the diversity of national immigration policies, social protection systems, and school integration models, no study has attempted to quantify and explain this variability using a globally representative sample.

Large scale international educational assessments such as the Programme for International Student Assessment (PISA), the Trends in International Mathematics and Science Study (TIMSS), and the Progress in International Reading Literacy Study (PIRLS) offer valuable opportunities to examine adolescent outcomes across countries. Among these assessments, PISA is one of the most comprehensive, assessing 15 year old students and covering approximately 90 per cent of the global economy [20]. Developed by the Organisation for Economic Cooperation and Development (OECD), PISA has expanded from 35 participating countries in 2000 to 81 countries in the 2022 assessment cycle, the most recent assessment cycle [20].

Although primarily designed to assess academic performance, PISA uses standardised instruments that generate robust data suitable for broader applications, including epidemiological research on adolescent mental health and well being. Conducted after the primary COVID 19 pandemic wave, the PISA 2022 assessment cycle incorporated a retrospective module on COVID 19 related school disruption, enabling the concurrent measurement of school closure experiences, psychosomatic symptoms, and social well being within a single instrument and sampling framework. In addition, the multilevel and cross national design of PISA allows for the simultaneous estimation of student level,

school level, and country level predictors, making it possible to assess individual-level associations between immigrant background and COVID 19 related school closure and mental health and well being outcomes, as well as to examine cross-national variation in these associations using internationally comparable data.

Objectives

This study aimed to: (1) estimate the association between COVID-19-related school closures and psychosomatic symptoms and life satisfaction among 15-year-old adolescents; (2) assess whether immigrant background, distinguishing native-born students, second-generation immigrants, and first-generation immigrants, moderates this association; (3) examine loneliness during school closures, family support, and school belonging as potential mediating mechanisms linking immigrant background and exposure to school closures with psychosomatic symptoms and life satisfaction; and (4) quantify cross-national variation in the differential effects of school closures on immigrant versus native-born adolescents.

Methods

Participants

Public use data from the 2022 cycle of the Programme for International Student Assessment (PISA 2022) were analysed. PISA is a cross sectional complex survey employing multistage sampling, unequal sampling probabilities, and stratification. It is administered internationally every three years to 15 year old students in Organisation for Economic Co-operation and Development (OECD) member countries and participating non member countries. The 2022 cycle included 81 countries and economies, yielding an analytic base of approximately 613,000 students nested within around 22,000 schools [20]. As psychosomatic symptom and life satisfaction data were not collected in all participating countries, the analysis was restricted to students from the 13 countries in which these data were available, comprising 122,465 students nested within approximately 4,401 schools.

The country-specific sample sizes were as follows: Brazil, 10,798 students from 598 schools; Hong Kong, 5,907 students from 163 schools; Hungary, 6,198 students from 262 schools; Ireland, 5,569 students from 170 schools; Macao, 4,384 students from 46 schools; Mexico, 6,288 students from 280 schools; the Netherlands, 5,046 students from 154 schools; New Zealand, 4,682 students from 169 schools; Panama, 4,544 students from 215 schools; Saudi Arabia, 6,928 students from 193 schools; Slovenia, 6,721 students from 345 schools; Spain, 30,800 students from 966 schools; and the United Arab Emirates, 24,600 students from 840 schools.

All data are publicly available and fully anonymised. Ethical approval and informed consent were obtained at the national level by countries participating in PISA. No additional ethics approval was required for this secondary analysis [21].

Measures

Measures were organised according to the multilevel structure of the data, reflecting student, school, and country contexts. Several measures were operationalised using PISA composite Weighted Likelihood Estimate (WLE) indices. WLE scoring is an item response theory-based approach that produces person-level latent trait estimates while correcting for measurement error. All WLE indices used in the present study were standardised to a mean of zero and a standard deviation of one across the international PISA population, and demonstrated adequate cross-national measurement invariance across countries and language groups [21]. Further details on index construction and validation are provided in the PISA 2022 Technical Report [21].

Outcomes

The outcomes were psychosomatic symptoms and life satisfaction, both operationalised using PISA WLE indices as described above. The primary outcome was psychosomatic symptoms, assessed using the PISA 2022 Psychosomatic Symptoms index. This index was derived from nine items asking students how frequently, over the past six months, they had experienced headache, stomach pain, back pain, feelings of depression, irritability, nervousness, difficulty falling asleep, dizziness, and anxiety. Each item was rated on a five point Likert type scale (1 = rarely or never, 2 = about monthly, 3 = about weekly, 4 = more than once a week, and 5 = about daily). Higher scores on the psychosomatic symptom index indicate greater symptom frequency.

Life satisfaction was the secondary outcome, assessed using the PISA 2022 Life Satisfaction index. The index was derived from ten domain specific satisfaction items covering satisfaction with health, physical appearance, schoolwork, friendships, neighbourhood, material possessions, use of time, relationships with parents, relationships with teachers, and school life. Each item was rated on a four-point Likert-type scale (1 = not at all satisfied, 2 = not satisfied, 3 = satisfied, and 4 = totally satisfied). Higher scores on the life satisfaction index indicate greater overall life satisfaction.

Exposure

Exposure to COVID-19-related school closure was operationalised as a school-level variable derived from student-reported data. It was assessed using a direct binary item asking students, “In the last three years, did your school close more than six months because of COVID-19?” (yes/no). A second item capturing school closures due to other reasons, such as natural disasters, strikes, or pollution, was retained as a negative control exposure (yes/no). If the observed association with outcomes is specific to COVID-19-related closures rather than to school closure per se, this item would be expected to yield a null or attenuated association.

Moderator: immigrant background

Immigrant background was operationalised as a student-level variable, following the OECD standard three-category classification derived from country-of-birth information for the student and both parents [21]. Students were classified as native born if the student and at least one parent were born in the country of assessment; as second generation immigrants if the student was born in the country of assessment but both parents were born abroad; and as first generation immigrants if the student and both parents were born outside the country of assessment.

Mediators

Three mediating variables were grounded in prior theoretical and empirical literature and operationalised as student-level variables [3, 8, 15–17]. These mediators were loneliness during school closures, family support, and school belonging. Loneliness during school closures was the primary hypothesised mediator, reflecting the central role of social isolation in linking school closure to deterioration in mental health. Loneliness was assessed using a single item rated on a four-point Likert-type scale: “I felt lonely during school closures” (1 = strongly disagree, 2 = disagree, 3 = agree, and 4 = strongly agree).

Family support and school belonging were both operationalised using PISA WLE indices, as previously described. Family support was assessed using an index derived from ten items assessing the frequency of parental engagement in school related conversations, shared meals, and expressions of interest in the student’s educational progress. Each item was rated on a five-point Likert-type scale (1 = never or almost never, 2 = about once or twice a year, 3 = about once or twice a month, 4 = about once or twice a week, and 5 = every day or almost every day).

School belonging was assessed using the PISA School Belonging index, derived from six items assessing perceived inclusion, ease of friendship formation, and freedom from loneliness at school. As a pre-pandemic attitudinal measure, school belonging was treated as a moderator of the impact of closure-induced social deprivation rather than as a consequence of school closures. Each item was rated on a four-point Likert-type scale (1 = strongly disagree, 2 = disagree, 3 = agree, and 4 = strongly agree).

Covariates

Covariates were specified a priori on substantive grounds, informed by previous evidence linking them to adolescent mental health outcomes and or immigration origin, and are organised according to the multilevel structure of the data [5, 8, 15, 17].

Student-level covariates captured individual demographic, socioeconomic, behavioural, and COVID-related factors that could confound associations between school closure exposure, mediating mechanisms, and mental health outcomes. These included sex (male/female), age (in years), socioeconomic, social, and cultural status (PISA WLE index), grade repetition (yes/no), and language spoken at home (language of the test country: yes/no)

School-level covariates were operationalised as school-level means of student-reported variables, all assessed using PISA WLE indices, thereby reflecting aggregated characteristics of the school environment. These included teacher support and disciplinary climate. At the country level, a binary indicator of OECD membership was included to capture broad institutional and economic differences between education systems. In supplementary analyses, total country-level school-closure duration, measured in days (including both full and partial closures), was incorporated. These data were derived from UNESCO administrative sources covering the period from 16 February 2020 to 30 April 2022 and merged with the student-level dataset by country code to triangulate the individual-level self-reported school-closure measure (see Supplementary Material) [22]. Of the 13 countries included in the analytic sample, 11 had direct entries in the UNESCO database; Hong Kong and Macao, which are not listed independently, were assigned the value for mainland China as a proxy. The UNESCO school-closure duration variable was standardised to a z-score across the analytic sample.

Analysis

Analyses were conducted using pooled data across countries using Python (version 3.10.12; Python Software Foundation). Statistical significance was set at $p < 0.05$. All analyses adhered to OECD recommendations for analysing PISA data, incorporating final student weights and replicate weights to ensure population-representative estimates and correct statistical inference under the complex survey design [21].

Multilevel model specification

To assess the relationship between COVID-19-related school closures and psychosomatic symptoms and life satisfaction, adjusted linear regression models with school-level random effects were employed. Students (Level 1) were nested within schools (Level 2), and country-level heterogeneity was accounted for through the inclusion of country fixed effects rather than a random intercept at the country level, given the limited number of countries available ($n = 13$) and to avoid the instability in variance component estimation associated with small numbers of higher-level units [23]. For each outcome, models were built in five sequential steps: (1) an unconditional model with no predictors (null model); (2) addition of Level 1 covariates and immigrant background (Model 1); (3) addition of Level 2 covariates and school-level COVID-19 closure (Model 2); (4) addition of Level 3 covariates (Model 3); and (5) inclusion of interaction terms between immigrant background and COVID-19 school closure (Model 4). To quantify cross-national variation in the differential effects of school closures on immigrant versus native-born adolescents, this final step was repeated stratified by country.

The necessity of the multilevel structure was evaluated using intraclass correlation coefficients derived from the unconditional model, indicating non-negligible clustering at both the school and country levels. Standard errors were clustered by school throughout, using the Huber-White sandwich estimator to obtain robust inference under the complex PISA sampling design. Random slopes were not included in the analyses. Instead, heterogeneity in associations was examined through explicitly modelled interaction terms and country-stratified analyses, prioritising a theory-driven and interpretable assessment of effect modification rather than modelling unstructured variance in slopes, in line with established methodological guidance on multilevel modelling [24].

Mediation analysis

Indirect pathways linking the immigrant background $\times$ COVID-19-related school closure interaction to psychosomatic symptoms and life satisfaction were assessed using a product-of-coefficients approach within a multilevel mediation framework. This approach decomposes the total effect of an exposure into indirect components operating through hypothesised mediators and a residual direct component [25]. Each of the three pre-specified mediators was analysed separately to assess its contribution to the observed associations. For each mediator, two regression models were estimated. First, a multilevel model predicted the mediator as a function of the immigrant background $\times$ COVID-19-related school closure interaction and the full set of covariates (path a). Second, a multilevel model predicted the outcome from the mediator, the immigrant background $\times$ school closure interaction, and the same covariates (path b). Indirect effects were calculated as the product of the corresponding a and b coefficients, in line with established approaches for testing indirect pathways of interaction effects [26].

All mediation models retained the hierarchical structure of the data, with students nested within schools and schools nested within countries, in order to account for clustering and unobserved contextual heterogeneity [24, 27]. The same covariates included in the primary outcome models were retained at each stage of the mediation analysis to ensure consistency across analyses and to reduce confounding of indirect effect estimates.

Statistical inference for indirect effects was based on non-parametric bootstrap procedures with 10,000 replications, given the non-normal sampling distribution of indirect effects [28, 29]. For each bootstrap sample, indirect effects were re-estimated, and percentile-based confidence intervals were derived from the empirical distribution of the bootstrapped estimates. Given the cross-sectional nature of the data, mediation results are interpreted as identifying indirect pathways consistent with the proposed theoretical framework rather than as evidence of causal mechanisms.

Sensitivity analysis

To assess whether the findings were robust to the operationalisation of the school-closure exposure, a sensitivity analysis was conducted in which the binary self-reported COVID-19 school-closure item was replaced with a continuous country-level measure of school-closure duration derived from UNESCO administrative data. In this sensitivity model, the individual-level binary school-closure item was replaced by the country-level UNESCO-derived school-closure duration z-score, while retaining all student-, school-, and country-level variables included in the primary models. Interaction terms between immigrant background and UNESCO-derived school-closure duration were also estimated to assess whether the differential effects of national-level closure duration on psychosomatic symptoms and life satisfaction varied by immigrant generation, in a manner analogous to the primary interaction analysis. Standard errors were clustered at the school level throughout.

Results

Sample characteristics

The analytic samples comprised 88,430 students nested within 4,203 schools with complete information on psychosomatic symptoms and 87,832 students nested within 4,200 schools with complete information on life satisfaction, both samples spanning 13 countries. The distribution of sample characteristics is presented in Table 1. The two samples differ in size because life satisfaction has a greater proportion of missing data than psychosomatic symptoms in the raw dataset; the difference is attributable to 598 students with missing life-satisfaction data who were retained in the psychosomatic-symptoms sample. Country-specific distributions of sample characteristics for the 13 countries are reported in Supplementary Table 1.

Table 1

Sample characteristics of the analytic samples for psychosomatic symptoms and life satisfaction. PISA 2022.

	Psychosomatic symptoms sample (N = 88,430*)	Life satisfaction sample (N = 87,832*)
	N (%)	N (%)
<i>Student-level</i>		
Immigrant background (ref. Native-born)		
2nd generation	10,071 (11.4)	9,999 (11.4)
1st generation	10,274 (11.6)	10,202 (11.6)
Sex (female)	44,793 (50.7)	44,498 (50.6)
Age (in years; mean, SD)	15.81 (0.29)	15.81 (0.29)
ESCS (PISA WLE index; mean, SD ^a)	-0.01 (0.99)	-0.01 (0.99)
Grade repetition (yes)	9,869 (11.2)	9,756 (11.1)
Language spoken at home (language of the test country; yes)	73,094 (82.7)	72,676 (82.7)
<i>School-level</i>		
COVID-19 school closure (yes)	30,148 (34.1)	29,887 (34.0)
Teacher support (PISA WLE index; mean, SD ^a)	0.12 (1.14)	0.12 (1.14)
Disciplinary climate (PISA WLE index; mean, SD ^a)	0.08 (0.97)	0.08 (0.97)
<i>Country-level</i>		
OECD membership (yes)	52,157 (59.0)	51,916 (59.1)
ESCS = Index of Economic, Social and Cultural Status. PISA WLE index: item response theory-based composite measures standardised to a mean of 0 and a standard deviation of 1 in the international PISA population. SD: Standard deviation. School- and country-level characteristics are presented as student-weighted distributions and therefore reflect the proportion of students attending schools with these characteristics or residing in countries with these characteristics, rather than characteristics of schools or countries per se. *The psychosomatic symptoms sample included 4,203 schools across 13 countries; the life satisfaction sample included 4,200 schools across 13 countries.		

Associations between immigrant origin, COVID-19-related school closures, and psychosomatic symptoms

Table 2 presents the associations between immigrant origin, COVID-19-related school closures, and psychosomatic symptoms. After adjustment for student-, school-, and country-level variables, psychosomatic symptom levels were lower among first-generation immigrant students and higher among second-generation immigrant students compared with their native-born peers. On average, psychosomatic symptom levels were 0.048 standard deviations lower (95% CI: -0.077; -0.018) among first-generation immigrants and 0.030 standard deviations higher (95% CI: 0.006; 0.055) among second-generation immigrants compared with native-born students (Table 2, Model 3).

Table 2

Associations between immigrant origin and COVID-19-related school closures with psychosomatic symptoms and life satisfaction. PISA 2022.

	Psychosomatic symptoms (N = 88,430 students; 4,203 schools; 13 countries)		Life satisfaction (N = 87,832 students; 4,200 schools; 13 countries)	
	b (CI95%)	p-value	b (CI95%)	p-value
Null model				
<i>ICC (%) school</i>	5.9%		7.2%	
Model 1				
Immigrant background (ref. Native-born)				
1st generation	-0.057 (-0.087; -0.027)	< 0.001	-0.074 (-0.110; -0.037)	< 0.001
2nd generation	0.027 (0.002; 0.051)	0.033	-0.110 (-0.139; -0.080)	< 0.001
<i>ICC (%) school</i>	2.7%		4.0%	
Model 2				
Immigrant background (ref. Native-born)				
1st generation	-0.048 (-0.077; -0.018)	0.001	-0.096 (-0.130; -0.061)	< 0.001
2nd generation	0.030 (0.006; 0.055)	0.015	-0.119 (-0.148; -0.091)	< 0.001
COVID-19 school closure (yes)	0.117 (0.102; 0.133)	< 0.001	0.007 (-0.011; 0.025)	0.448
<i>ICC (%) school</i>	2.4%		2.9%	
Model 3				
Immigrant background (ref. Native-born)				
1st generation	-0.048 (-0.077; -0.018)	0.001	-0.096 (-0.130; -0.061)	< 0.001
2nd generation	0.030 (0.006; 0.055)	0.015	-0.119 (-0.148; -0.091)	< 0.001
COVID-19 school closure (yes)	0.117 (0.102; 0.133)	< 0.001	0.007 (-0.011; 0.025)	0.448
<i>ICC (%) school</i>	2.3%		2.9%	
All models are three-level multilevel linear regression models with students nested within schools and schools nested within countries. Student-level (Level 1) variables include immigrant background, sex, age, economic, social and cultural status (ESCS), grade repetition, and language spoken at home. School-level (Level 2) variables include COVID-19-related school closure, teacher support, and disciplinary climate. Country-level (Level 3) variable includes OECD membership. Null model: a multilevel model with no predictor. Model 1 includes student-level variables only. Model 2 includes student- and school-level variables. Model 3 includes student-, school-, and country-level variables. Model 4 additionally includes interaction terms between immigrant background and COVID-19-related school closure. ICC: Intraclass correlation coefficient. 95%CI: 95% confidence interval. Covariates not shown.				

	Psychosomatic symptoms (N = 88,430 students; 4,203 schools; 13 countries)		Life satisfaction (N = 87,832 students; 4,200 schools; 13 countries)	
	b (CI95%)	p-value	b (CI95%)	p-value
Null model				
Model 4				
Immigrant background (ref. Native-born)				
1st generation	-0.029 (-0.062; 0.004)	0.081	-0.081 (-0.117; -0.045)	< 0.001
2nd generation	0.032 (0.005; 0.059)	0.021	-0.080 (-0.110; -0.051)	< 0.001
COVID-19 school closure (yes)	0.125 (0.106; 0.143)	< 0.001	0.028 (0.008; 0.048)	0.007
Immigrant background (ref. Native-born) × COVID-19 school closure				
1st generation	-0.049 (-0.094; -0.003)	0.038	-0.049 (-0.101; 0.003)	0.067
2nd generation	-0.006 (-0.052; 0.041)	0.816	-0.126 (-0.176; -0.076)	< 0.001
ICC (%) school	2.3%		2.9%	
All models are three-level multilevel linear regression models with students nested within schools and schools nested within countries. Student-level (Level 1) variables include immigrant background, sex, age, economic, social and cultural status (ESCS), grade repetition, and language spoken at home. School-level (Level 2) variables include COVID-19-related school closure, teacher support, and disciplinary climate. Country-level (Level 3) variable includes OECD membership. Null model: a multilevel model with no predictor. Model 1 includes student-level variables only. Model 2 includes student- and school-level variables. Model 3 includes student-, school-, and country-level variables. Model 4 additionally includes interaction terms between immigrant background and COVID-19-related school closure. ICC: Intraclass correlation coefficient. 95%CI: 95% confidence interval. Covariates not shown.				

COVID-19-related school closures were consistently and positively associated with psychosomatic symptoms. In models adjusted for student-, school-, and country-level variables, students attending schools that experienced closures reported, on average, psychosomatic symptom levels that were 0.117 standard deviations higher than those attending schools without closures (95% CI: 0.102; 0.133; Table 2, Model 3). After the inclusion of interaction terms between immigrant background and COVID-19-related school closures, the association between school closure and psychosomatic symptoms differed only for first-generation immigrants ($b = -0.049$, 95% CI: -0.094 ; -0.003 ; Table 2, Model 4).

In the null multilevel model, the intraclass correlation coefficient (ICC) indicated that 5.1% and 1.1% of the total variation in psychosomatic symptoms were attributable to between-school and between-country differences, respectively. Estimates for covariates are presented in Supplementary Table 2. Across all models, female students reported higher levels of psychosomatic symptoms than male students. Higher socioeconomic, social, and cultural status, as well as grade repetition, were also associated with increased symptom levels, whereas greater teacher support, a more positive disciplinary climate, and residence in an OECD member country were associated with lower levels of psychosomatic symptoms.

Associations between immigrant origin, COVID-19-related school closures, and life satisfaction

Life satisfaction levels were consistently lower among first- and second-generation immigrant students than among their native-born peers. After adjusting for student-, school-, and country-level variables. On average, life satisfaction was 0.096 standard deviations lower (95% CI: -0.130; -0.061) among first-generation immigrants and 0.119 standard deviations lower (95% CI: -0.148; -0.091) among second-generation immigrants compared with native-born students (Table 2, Model 3).

COVID-19-related school closures were not associated with life satisfaction in models without interaction terms (Table 2, Models 2 and 3). However, a negative interaction was observed between second-generation immigrant background and COVID-19-related school closures ($b = -0.084$; 95% CI: -0.133; -0.035; Table 2, Model 4). No interaction was observed for first-generation immigrants ($b = -0.010$; 95% CI: -0.057; 0.037).

In the null multilevel model, the intraclass correlation coefficient (ICC) indicated that 6.6% and 2.8% of the total variation in life satisfaction were attributable to between-school and between-country differences, respectively. Estimates for covariates are presented in Supplementary Table 3. Across all models, female students reported lower levels of life satisfaction than male students. Grade repetition and residence in an OECD member country were also associated with lower life satisfaction, whereas higher socioeconomic, social, and cultural status, speaking the language of the test country at home, greater teacher support, and a more positive disciplinary climate were associated with higher levels of life satisfaction.

Mediation analyses

Mediation of psychosomatic symptoms

Mediation analyses examining the roles of loneliness during school closures, family support, and school belonging in the association between COVID-19-related school closures and psychosomatic symptoms among first- and second-generation immigrant students, relative to native-born peers, are presented in Table 3. Loneliness during school closures and family support were not supported as mediating pathways for either immigrant generation, as indirect effects were null for both groups. School belonging emerged as the only mediating pathway. Compared with native-born students, second-generation immigrant students reported lower levels of school belonging ($b = -0.079$, 95% CI: -0.144; -0.013; path a, Table 3). Each one-point increase on the school belonging scale was associated, on average, with a 0.160 standard deviation decrease in psychosomatic symptom levels (95% CI: -0.170; -0.150; path b, Table 3), yielding a positive indirect effect for second-generation immigrants ($b = 0.013$, 95% CI: 0.002; 0.023). No mediating pathway through school belonging was identified for first-generation immigrants.

Table 3

Mediation analysis: indirect effects of the immigrant background × COVID-19 school closure interaction on psychosomatic symptoms via three pre-specified mediators (N = 88,430 students; 4,203 schools; 13 countries). PISA 2022.

Mediator	Path a: 2nd generation × COVID closure → Mediator		Path a: 1st generation × COVID closure → Mediator		Path b: Mediator → Psychosomatic symptoms		Indirect effect: 2nd generation×COVID → Mediator → Psychosomatic symptoms		Indirect effect: 1st generation×COVID → Mediator → Psychosomatic symptoms	
	b (CI95%)	p-value	b (CI95%)	p-value	b (CI95%)	p-value	b (CI95%)	p-value	b (CI95%)	p-value
Loneliness during school closures	0.045 (-0.018; 0.109)	0.163	0.008 (-0.054; 0.070)	0.802	0.241 (0.231; 0.252)	< 0.001	0.011 (-0.005; 0.026)	0.164	0.002 (-0.013; 0.017)	0.794
Family support	0.006 (-0.061; 0.074)	0.851	-0.017 (-0.083; 0.048)	0.603	-0.063 (-0.073; -0.053)	< 0.001	-0.001 (-0.005; 0.004)	0.663	0.001 (-0.003; 0.005)	0.624
School belonging	-0.079 (-0.144; -0.013)	0.018	-0.003 (-0.067; 0.060)	0.918	-0.160 (-0.170; -0.150)	< 0.001	0.013 (0.002; 0.023)	0.015	0.001 (-0.010; 0.011)	0.852

All models are three-level multilevel linear regression models with students nested within schools and schools nested within countries. Path a models predict each mediator from the interaction term (2nd generation × COVID-19 school closure and 1st generation × COVID-19 school closure), the main effects of immigrant background and COVID-19 school closure and student-, school-, and country-level covariates. Path b models predict psychosomatic symptoms from the mediator, the interaction terms, and the same set of covariates. Indirect effects are calculated as the product of the corresponding path a and path b coefficients. 95%CI: 95% confidence interval. Student-level (Level 1) variables include immigrant background, sex, age, economic, social and cultural status (ESCS), grade repetition, and language spoken at home. School-level (Level 2) variables include COVID-19-related school closure, teacher support, and disciplinary climate. Country-level (Level 3) variable includes OECD membership. Covariates not shown.

Mediation of life satisfaction

Table 4 presents mediation analyses examining the roles of loneliness during school closures, family support, and school belonging in the association between COVID-19-related school closures and life satisfaction among first- and second-generation immigrant students, compared with their native-born peers. Loneliness during school closures and family support were not supported as mediating pathways for either immigrant generation, as indirect effects were null for both groups. School belonging emerged as the only mediating pathway.

Table 4

Mediation analysis: indirect effects of the immigrant background × COVID-19 school closure interaction on life satisfaction via three pre-specified mediators (N = 87,832 students; 4,200 schools; 13 countries). PISA 2022.

Mediator	Path a: 2nd generation × COVID closure → Mediator		Path a: 1st generation × COVID closure → Mediator		Path b: Mediator → Life satisfaction		Indirect effect: 2nd generation × COVID → Mediator → Life satisfaction		Indirect effect: 1st generation × COVID → Mediator → Life satisfaction	
	b (CI95%)	p-value	b (CI95%)	p-value	b (CI95%)	p-value	b (CI95%)	p-value	b (CI95%)	p-value
Loneliness during school closures	0.045 (– 0.018; 0.109)	0.163	0.008 (– 0.054; 0.070)	0.802	–0.125 (– 0.136; –0.114)	< 0.001	–0.006 (– 0.014; 0.002)	0.163	–0.001 (– 0.009; 0.007)	0.806
Family support	0.006 (– 0.061; 0.074)	0.851	–0.017 (– 0.083; 0.048)	0.603	0.225 (0.215; 0.236)	< 0.001	0.002 (– 0.014; 0.017)	0.850	–0.004 (– 0.019; 0.011)	0.601
School belonging	–0.079 (– 0.144; –0.013)	0.018	–0.003 (– 0.067; 0.060)	0.918	0.308 (0.298; 0.319)	< 0.001	–0.024 (– 0.044; –0.004)	0.018	–0.001 (– 0.021; 0.019)	0.922

All models are three-level multilevel linear regression models with students nested within schools and schools nested within countries. Path a models predict each mediator from the interaction term (2nd generation × COVID-19 school closure and 1st generation × COVID-19 school closure), the main effects of immigrant background and COVID-19 school closure and student-, school-, and country-level covariates. Path b models predict life satisfaction from the mediator, the interaction terms, and the same set of covariates. Indirect effects are calculated as the product of the corresponding path a and path b coefficients. 95%CI: 95% confidence interval. Student-level (Level 1) variables include immigrant background, sex, age, economic, social and cultural status (ESCS), grade repetition, and language spoken at home. School-level (Level 2) variables include COVID-19-related school closure, teacher support, and disciplinary climate. Country-level (Level 3) variable includes OECD membership. Covariates not shown.

School belonging functioned as a mediating pathway for second-generation immigrant students. Compared with their native-born peers, second-generation immigrant students reported lower levels of school belonging, corresponding to a decrease of 0.079 standard deviations (95% CI: –0.144; –0.013; path a, Table 4). Lower levels of school belonging were, in turn, associated with higher life satisfaction (b = 0.308, 95% CI: 0.298; 0.319; path b, Table 4), resulting in a negative indirect effect (b = – 0.024, 95% CI: –0.044; –0.004). No mediating pathway through school belonging was identified for first-generation immigrants.

Cross-national heterogeneity in the effects of COVID-19-related school closures by immigrant background

Country-stratified analyses of differences in psychosomatic symptoms and life satisfaction among students exposed to COVID-19-related school closures are shown in Fig. 1. Regarding psychosomatic symptoms, a difference between first-generation immigrant students and their native-born peers was observed only in the United Arab Emirates. Among students exposed to COVID-19-related school closures, first-generation immigrants reported, on average, 0.085 standard deviations lower levels of psychosomatic symptoms than native-born students whose schools were also closed due to COVID-19 (95% CI: –0.146; –0.025; Fig. 1a). No country-level differences in psychosomatic symptoms were observed for second-generation immigrant students.

Country-stratified analyses showed immigrant–native differences in the association between COVID-19-related school closures and life satisfaction among first-generation immigrants in the United Arab Emirates and Saudi Arabia. In these

countries, first-generation immigrants reported, on average, 0.293 and 0.151 standard deviations lower levels of life satisfaction, respectively, than native-born students whose schools were also closed due to COVID-19 (95% CI: -0.517; -0.070 and -0.224; -0.077, respectively; Fig. 2a). Among second-generation immigrants, differences relative to native-born students were observed in Spain, Ireland, the United Arab Emirates, and Saudi Arabia, where lower levels of life satisfaction were reported among second-generation immigrants exposed to COVID-19-related school closures. No countries exhibited positive differences.

Negative control analysis

The negative control analysis replacing the COVID-19 school-closure exposure with school closures due to other reasons (natural disasters, strikes, or pollution) is presented in Supplementary Tables 4 and 5. After adjustment for student-, school-, and country-level variables, school closures due to other reasons were also positively associated with psychosomatic symptoms ($b = 0.201$, 95% CI: 0.185; 0.217; Supplementary Table 4, Model 3). Following the inclusion of interaction terms between immigrant background and other-reason school closures, the association between school closure and psychosomatic symptoms differed only for first-generation immigrants, but in the opposite direction to that observed for COVID-19-related school closures ($b = 0.064$, 95% CI: 0.009; 0.119; Supplementary Table 4, Model 4).

Regarding life satisfaction, school closures due to other reasons were negatively associated with life satisfaction across all models (Supplementary Table 5). In contrast to the COVID-19 school-closure exposure, the inclusion of interaction terms did not show differences in the association between school closures due to other reasons and life satisfaction by immigrant background (first-generation immigrants: $b = 0.005$, 95% CI: -0.055; 0.066; second-generation immigrants: $b = 0.020$, 95% CI: -0.035; 0.075; Supplementary Table 5, Model 4).

Sensitivity analysis

Supplementary Table 6 presents two sensitivity analysis models conducted to triangulate the self-reported COVID-19 school-closure item with country-level administrative data on school-closure duration derived from UNESCO (2023). When the self-reported school-closure item was replaced by the UNESCO-derived measure, each one-standard-deviation increase in country-level school-closure duration (z-score) was associated, on average, with an increase of 0.089 standard deviations in psychosomatic symptom levels and an increase of 0.092 standard deviations in life satisfaction (95% CI: 0.065 to 0.114 and 0.066; 0.119, respectively; Supplementary Table 6, Model 1). Regarding immigrant background, first-generation immigrants continued to report fewer psychosomatic symptoms than native-born peers ($b = -0.050$, 95% CI: -0.080; -0.019). The interaction between first-generation immigrant background and UNESCO-derived school-closure duration was negative for psychosomatic symptoms ($b = -0.035$, 95% CI: -0.066; -0.005). For life satisfaction, both immigrant generations reported lower levels than native-born students, and interactions with UNESCO-derived school-closure duration were negative for both groups (first-generation immigrants: $b = -0.077$, 95% CI: -0.111; -0.042; second-generation immigrants: $b = -0.061$, 95% CI: -0.096; -0.027).

In models including both the self-reported COVID-19 school-closure item and the UNESCO-derived school-closure duration z-score as exposures, the self-reported closure item retained its positive association with psychosomatic symptoms ($b = 0.121$, 95% CI: 0.103; 0.140; Supplementary Table 6, Model 2), and the interaction between second-generation immigrant background and self-reported COVID-19 closure remained negative for life satisfaction ($b = -0.109$, 95% CI: -0.160; -0.058). The interaction between first-generation immigrant background and UNESCO-derived school-closure duration also remained negative for life satisfaction ($b = -0.075$, 95% CI: -0.110; -0.040), and the interaction between second-generation immigrant background and UNESCO-derived school-closure duration was observed ($b = -0.043$, 95% CI: -0.078; -0.008).

Discussion

The present study examined associations between COVID-19-related school closures and two indicators of adolescent mental health, psychosomatic symptoms and life satisfaction, among fifteen-year-old students from 13 countries participating in PISA 2022, with particular attention to differences by immigrant background. Four key findings were identified. COVID-19-related school closures were consistently associated with higher levels of psychosomatic symptoms, an association that remained robust when school closures were operationalised using UNESCO-derived country-level duration data. First-generation immigrant students reported lower levels of psychosomatic symptoms than native-born peers. In contrast, reduced life satisfaction among students exposed to school closures was observed only among second-generation immigrant students, with no corresponding differences for psychosomatic symptoms and no similar pattern among first-generation immigrants. Finally, school belonging was identified as the sole mediating pathway linking school closures to both increased psychosomatic symptoms and reduced life satisfaction among second-generation immigrant students.

Adolescent outcomes varied across individual, school, and country contexts. Although the intraclass correlation coefficients indicated that most of the variance in psychosomatic symptoms and life satisfaction was attributable to individual-level differences, the proportion explained at the school level was non-negligible. Given the clustered sampling design of PISA, the school-level exposure to COVID-19-related school closures, and the theoretical interest in contextual and cross-national variation, a multilevel modelling approach was therefore necessary to obtain valid inference.

The finding that COVID-19-related school closures were associated with elevated psychosomatic symptom levels is consistent with prior cross-national evidence demonstrating declines in adolescent mental health during the pandemic period. A systematic review reported robust associations between pandemic-related social restrictions, increased loneliness, and greater depressive symptomatology among children and adolescents, with effects persisting up to nine years later [6]. Cross-national analyses using data from the Health Behaviour in School-aged Children (HBSC) study similarly documented increases in the prevalence of daily psychosomatic complaints in the post-pandemic period across several countries [4].

The lower levels of psychosomatic symptoms observed among first-generation immigrant students align with the healthy immigrant effect, whereby recently arrived immigrants often exhibit more favourable health outcomes than native-born populations despite, on average, lower socioeconomic resources [8]. This paradoxical advantage has been attributed to positive health selection in migration processes, as well as to stronger family cohesion, cultural norms that discourage the expression of distress, and heightened motivation towards educational and social integration in host societies [8]. However, among students whose schools were closed due to COVID-19, first-generation immigrants exhibited a reduced differential advantage relative to native-born students in terms of psychosomatic symptoms, suggesting that pandemic-related disruptions may have attenuated, though not eliminated, the protective effect typically observed in this group.

In contrast, the finding that second-generation immigrant students exposed to COVID-19-related school closures reported lower life satisfaction than their native-born peers represents a more novel contribution. Prior HBSC-based research conducted before the pandemic demonstrated that both first- and second-generation immigrant adolescents tended to report higher levels of life dissatisfaction and psychosomatic symptoms than native-born adolescents, with school- and country-level social capital accounting for part of these disparities [11]. The present findings suggest that COVID-19 school closures introduced an additional source of disadvantage specifically for second-generation immigrant adolescents in the domain of life satisfaction, without a corresponding amplification of psychosomatic symptoms. This pattern may reflect the distinct psychosocial role of schools for second-generation immigrants, for whom school constitutes a key site of social integration, peer relationships, and social recognition within the host

society [11]. Disruption of this integrative environment through prolonged closures may therefore have disproportionately undermined subjective well-being, even in the absence of heightened somatic symptom expression.

The mediation analyses provide partial support for the proposed interpretative framework. School belonging emerged as the only pathway through which COVID-19-related school closures were associated with both higher psychosomatic symptoms and lower life satisfaction among second-generation immigrant students. This finding is consistent with prior research highlighting the central role of schools in fostering social integration and psychosocial well-being, particularly for adolescents in vulnerable or marginalised positions [3]. It also aligns with theoretical perspectives that conceptualise schools as key institutional contexts supporting social identity formation and psychological belonging, especially for adolescents navigating multiple cultural reference frames [15]. By removing the institutional setting in which second-generation adolescents typically construct peer relationships and negotiate their social identities, school closures may have generated a sense of social displacement that is more directly reflected in measures of belonging and subjective well-being than in somatic symptom indices.

School closures due to non-COVID causes were positively associated with psychosomatic symptoms, similar to the pattern observed for COVID-19-related closures. This finding suggests that disruption of school attendance per se, regardless of the precipitating cause, is associated with greater psychosomatic symptom levels, consistent with the school-as-social-buffer hypothesis, which conceptualises schools as key institutions that provide social regulation, emotional support, and psychological stability for adolescents [3, 15]. However, the interaction between immigrant background and non-COVID school closures did not replicate the COVID-19-specific interaction for life satisfaction observed among second-generation immigrant students. This differential pattern, whereby the COVID-19 interaction for life satisfaction was not observed for closures due to other causes, points to features of the COVID-19 school-closure experience that extend beyond simple disruption of attendance. The pandemic context involved a confluence of social isolation, perceived health threat, and family-level economic stress, which may have altered the relational fabric of school life for second-generation adolescents in ways not reproduced by shorter or cause-specific closures.

The sensitivity analysis, in which the self-reported binary school-closure item was replaced with UNESCO-derived country-level school-closure duration measured in days, yielded convergent results, strengthening confidence in the primary findings. However, longer durations of school closures at the national level were paradoxically associated with higher levels of life satisfaction. This association likely reflects residual confounding by national economic development, as countries with shorter closures, such as Spain and Ireland, tend to exhibit higher baseline levels of adolescent well-being than countries with longer closures, such as Panama and Mexico, rather than a genuine protective effect of closure duration [4, 11, 22].

The cross-national stratified analyses demonstrated considerable heterogeneity in immigrant–native differences across the 13 countries, consistent with prior cross-national evidence showing substantial contextual variation in adolescent mental health disparities. For life satisfaction among second-generation immigrants, disadvantages were concentrated in Spain, Ireland, the United Arab Emirates, and Saudi Arabia, countries that differ markedly in immigration policy, integration regimes, and the composition of their immigrant populations [30, 31]. The absence of country-level differences in most countries, alongside pronounced effects in a limited subset, suggests that pooled interaction estimates may mask meaningful contextual heterogeneity that warrants further investigation.

Strengths and limitations

This study has its strengths and limitations. The strengths include, first, the use of PISA 2022 data, which provide a large, nationally representative, and cross-nationally comparable sample of 15-year-old students across 13 countries with diverse economic, cultural, and immigration policy contexts. The stratified cluster sampling design with probability proportional to size, combined with the use of final student and replicate weights, ensures population-representative

estimates and appropriately accounts for the complex survey structure. Second, the inclusion of a negative control exposure and an objective external measure of school-closure duration derived from UNESCO administrative data strengthens the internal and construct validity of the findings. Finally, the multilevel cross-national design allows the simultaneous estimation of individual-, school-, and country-level associations and facilitates the assessment of cross-national heterogeneity in the effects of school closures by immigrant background.

It is important to consider that the data collected imposes limitations on the analyses. The most important limitation is the cross-sectional design. The cross-sectional sampling structure of PISA does not allow for the assessment of within-individual changes in mental health before and after school closures, which would provide more direct evidence of effects attributable to the closures. Pre-existing differences in mental health between immigrant and native-born adolescents, which cannot be fully accounted for within this design, may therefore have contributed to the observed interaction effects. Furthermore, given the cross-sectional nature of the data, indirect effects identified in the mediation analyses should be interpreted as indicative of potential mechanisms rather than as evidence of causal mediation. In addition, exposure to school closures was assessed using a single binary, retrospective self-report item, rendering this measure subject to recall bias and unable to capture heterogeneity in the nature or intensity of school closures. Finally, the generalisability of the findings is limited to the 13 countries with complete data available for analysis; as a result, countries with large immigrant populations and less well-resourced education systems may be underrepresented.

Conclusion

This cross-national study of adolescents across 13 countries demonstrates that COVID-19-related school closures were associated with a greater psychosomatic symptom burden, an effect that operated independently of individual socioeconomic disadvantage and was corroborated using objective country-level school-closure duration data. First-generation immigrant students exhibited a relative advantage in psychosomatic symptoms consistent with the healthy immigrant effect, although this advantage was attenuated among those whose schools closed due to COVID-19. Among second-generation immigrant adolescents, school closures due to COVID-19 were associated with lower life satisfaction compared with native-born peers in comparable circumstances. School belonging was identified as the mechanism through which COVID-19-related school closures translated into these differential outcomes, underscoring the role of schools as contexts of social integration for adolescents occupying an intermediate position between heritage and host cultures. These findings highlight the need, in future public health emergencies, to ensure that remote or hybrid learning environments actively promote school belonging and social inclusion, particularly among immigrant students. Such efforts may help mitigate the disproportionate mental health costs that large-scale educational disruptions impose on this group.

Declarations

Author Contribution

P.S.M.S. was responsible for the conceptualization, methodology, formal analysis, and investigation of the study, and for writing the original draft of the manuscript.

Data Availability

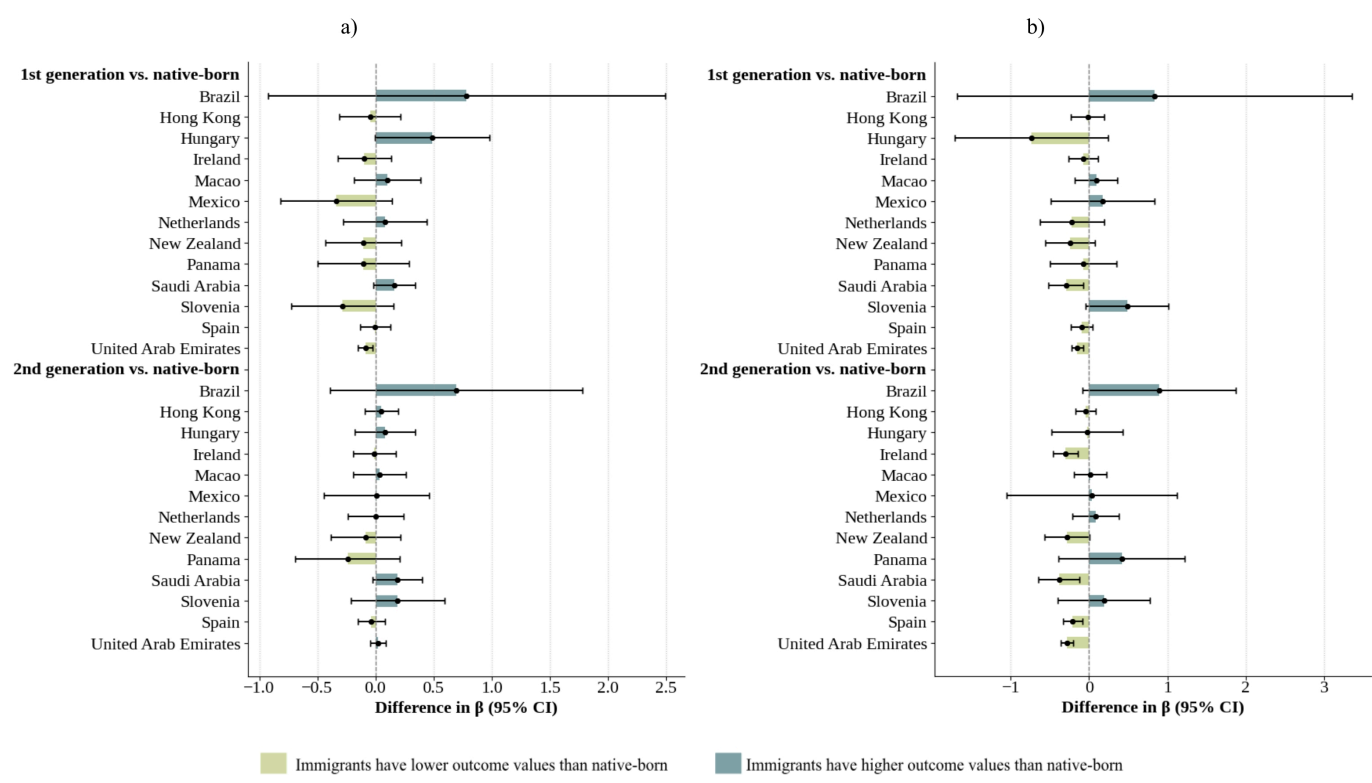
The data used in this study are publicly available and were obtained from the OECD PISA 2022 survey. The datasets can be accessed at: <https://survey.oecd.org/index.php?r=survey/index&sid=197663&lang=en>

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Figures



All models are three-level multilevel linear regression models with students nested within schools and schools nested within countries. Student-level (Level 1) covariates include sex, age, economic, social and cultural status (ESCS), grade repetition, and language spoken at home. School-level (Level 2) covariates include teacher support, and disciplinary climate. Country-level (Level 3) covariate includes OECD membership. All models include student-, school-, and country-level covariates. Model 1: UNESCO duration replaces self-reported COVID-19 school closure. Model 2: both exposures included simultaneously.

Figure 1

Country-stratified analyses of differences in psychosomatic symptoms and life satisfaction among students exposed to COVID-19-related school

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [SupplementaryTablesSchoolclosureduringCOVID19andpsychosomaticsymptoms.docx](#)