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Immigrant Generation and Adolescents' Sense of Belonging at School Across Three East Asian Education Systems

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Research Article

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Abstract

School belonging is a subjective dimension of adolescent psychosocial adjustment. Immigrant generation may mark different opportunities for social connection and experiences of acculturation, whose associations with belonging may depend on context. We compare PISA-defined native, second-generation, and first-generation students in Hong Kong (China), Singapore, and Macao (China), using PISA 2022 complete-case samples of 5,155, 6,357, and 4,183 students. System-specific weighted regressions adjust for sex, age, and socioeconomic status; inference uses 80 Fay-BRR replicate weights. The first-generation versus native coefficient is 0.100 in Hong Kong (95% CI [0.009, 0.190]) and 0.089 in Macao ([0.025, 0.153]); the second-generation coefficient is 0.082 in Singapore ([0.008, 0.155]). These estimates are small relative to within-group variation. Across the six primary generation-versus-native comparisons, Holm-adjusted p-values are .149, .040, and .149, respectively. Direct first-minus-second-generation contrasts have intervals spanning zero in all three systems. A joint cross-system test does not establish heterogeneous generation associations ($p = .482$), nor does it prove the associations equivalent. Excluded students differ from included students on observed characteristics, especially in Hong Kong; response-propensity weighting based on sex and age changes estimates little but cannot resolve unobserved selection. These findings qualify a general immigrant-disadvantage expectation for adolescent school belonging, while leaving the relational and acculturative processes underlying the associations unresolved. PISA categories describe birthplace patterns, not citizenship or legal status.

1. Introduction

Feeling that one belongs at school concerns more than participation in an educational institution. It involves adolescents' perceptions of acceptance, connection, and membership in a setting where much of their everyday social life takes place. Goodenow (1993) conceptualised school membership as a psychological experience, and belongingness theory places enduring interpersonal connection among basic human motivations (Baumeister & Leary, 1995). School belonging is therefore a meaningful aspect of psychosocial adjustment in its own right.

For adolescents from families with migration histories, a central question is how this subjective experience relates to the circumstances in which they enter and participate in school life. Being born elsewhere may entail changes in familiar relationships and school routines. Being locally born to parents born elsewhere may involve a different combination of continuity, family experience, and social expectations. Neither circumstance determines whether a young person feels accepted. Immigrant generation identifies a broad family birthplace pattern; the psychological experiences that might connect it to belonging remain heterogeneous within each category.

Existing evidence does not yield a uniform expectation of lower belonging among immigrant-background students. Chiu et al. (2012) reported an average native-student advantage in an international comparison, whereas Hong Kong studies reported patterns inconsistent with a general immigrant disadvantage (Cheung & Hui, 2003; Ni & Han, 2022). Research has also compared immigrant generations

in Australia (Allen et al., 2021) and connected acculturation orientations with school adjustment in European PISA samples (Schachner et al., 2017). The question is thus not whether migration and belonging have previously been studied. It is how consistently broad generation categories distinguish adolescents' sense of membership, and whether the apparent associations are demonstrably different across contexts when estimated on a common basis.

The present study addresses that question in Hong Kong (China), Singapore, and Macao (China) using PISA 2022. It extends the evidence through estimates from the same survey cycle, reporting the magnitude and precision of adjusted generation associations within each system. Direct first-versus-second-generation contrasts and a joint cross-system comparison distinguish the questions of generational and contextual variation. These estimates provide empirical constraints on accounts of adolescent belonging; the distinction between birthplace categories and psychological processes defines their interpretation, rather than constituting a new theoretical finding.

2. Conceptual framework and research questions

2.1. The need to belong in the school setting

The need-to-belong perspective provides the main framework for this study. Baumeister and Leary (1995) emphasised ongoing interpersonal bonds rather than social contact alone. Applied to school, this perspective directs attention to students' felt connection with others and their sense of being accepted. School-belonging research similarly identifies relationships within students' social environments as relevant correlates (Allen et al., 2018). The PISA belonging index captures reported experiences of membership, friendship, and isolation, providing a limited school-specific window on this relational domain.

A general need for connection does not predict that all social groups will report the same level of belonging, nor does it specify an inevitable disadvantage for students with migration histories. The relevant theoretical proposition is that circumstances affecting access to supportive relationships may be associated with felt membership. In this study, immigrant generation is a distal grouping variable that may coincide with such circumstances. It is not a direct measure of whether the need to belong has been satisfied, and a generation coefficient cannot isolate a relational mechanism.

2.2. Immigrant generation as a context for adjustment

An acculturation perspective offers a complementary account of why generation may be relevant. Adolescents and their families may navigate unfamiliar school routines, language practices, and expectations about social participation. First-generation students may have experienced a move themselves, whereas second-generation students were born in the receiving system. These classifications leave considerable variation in arrival timing, family histories, and everyday cultural experience. Schachner et al. (2017) examined acculturation orientations, belonging, and school adjustment in European PISA data.

Several plausible processes could lead to different observed patterns. Disrupted relationships or exclusion could accompany lower belonging; new friendships and welcoming school experiences could accompany stronger membership. These are possible explanations, not processes measured in the present models. Jain et al. (2026) reviewed multiple influences on immigrant adolescents' belonging, and Allen et al. (2021) compared school belonging across native-born and immigrant-generation groups in Australia. Together, this literature supports retaining generation distinctions without imposing a universal ordering from native to second- to first-generation students.

The mixed empirical record is important for that choice. Hong Kong evidence from primary pupils and from PISA secondary students differs from the average international pattern reported by Chiu et al. (2012) (Cheung & Hui, 2003; Ni & Han, 2022). Differences in measures, populations, and periods make these studies informative but not directly interchangeable. The remaining question concerns the direction, magnitude, and precision of comparable generation contrasts, rather than the discovery of a previously unstudied relationship.

2.3. Context and the interpretation of group differences

Context matters theoretically because the same birthplace classification may coincide with different opportunities for social connection. Research on integration-policy environments, inclusive school climates, and intercultural values has examined contextual correlates of belonging (Ham et al., 2017; Choi et al., 2025; Ordóñez-Carabaño et al., 2025). These studies provide reasons to examine variation rather than assume that a generation association travels unchanged between settings.

Hong Kong, Singapore, and Macao allow the same PISA-defined contrasts to be examined within a single survey cycle. The interpretation of birthplace categories is especially consequential: mobility across the boundaries of Hong Kong and Macao can involve mainland China, and the categories do not identify nationality or legal status. Nor should the three systems be treated as interchangeable examples of one East Asian cultural environment. Their comparison is useful as a focused assessment of whether generation associations are distinguishable across these sampled settings, not as a test of a specified cultural or institutional moderator.

The empirical gap has two parts. Separate group estimates do not establish a difference between immigrant generations, and different significance labels across systems do not establish contextual heterogeneity. Direct contrasts are needed for both questions. Applying them to contemporary, consistently measured data supplies a more bounded account of the relationship between demographic background and subjective belonging.

2.4. Research questions

RQ1: How are first- and second-generation immigrant backgrounds associated with school belonging relative to the PISA-defined native group within each system, before and after adjustment for sex, age, and socioeconomic status?

RQ2: Do the adjusted school-belonging contrasts differ directly between first- and second-generation students within each system?

RQ3: Do the adjusted immigrant-generation associations differ across Hong Kong, Singapore, and Macao?

Given the mixed evidence and the limited correspondence between birthplace and psychological experience, no uniform directional prediction is imposed. The home-versus-test-language adjustment is a secondary analysis of an additional correlate, not a test of acculturation or mediation. Selection and matched-measurement checks assess the dependence of the estimates on analytic choices without adding explanatory mechanisms.

3. Data and methods

3.1. Data and samples

The study uses the OECD PISA 2022 Student Questionnaire Public Use File in SPSS format and its official codebook, questionnaire, and technical report (OECD, 2024). PISA samples students around age 15 in participating education systems. We selected records whose CNT codes are HKG, SGP, and MAC, cross-checking CNTRYID values 344, 702, and 446. These selections yielded 5,907, 6,606, and 4,384 raw records, respectively, matching the official codebook frequencies. The three samples are analysed separately; student weights from different systems are not simply appended to fit one pooled regression.

The common analytic sample requires nonmissing school belonging, immigrant generation, sex, age, socioeconomic status, home-versus-test language, final weight, and all 80 positive replicate weights. The resulting samples are 5,155 in Hong Kong, 6,357 in Singapore, and 4,183 in Macao. The sequential sample flow and variable-specific missing counts are supplied in the reproducibility files; school and student identifiers are retained in the cleaned data for traceability. In Hong Kong, the largest initial losses were 293 students without BELONG and, among the remainder, 426 without IMMIG; a further 29 lacked ESCS and four lacked the language item. The corresponding unweighted exclusions are 752 of 5,907 (12.73%), 249 of 6,606 (3.77%), and 201 of 4,384 (4.58%). These are missing analysis variables among sampled students, separate from the OECD's school and student survey-response assessment.

3.2. Measures

The outcome, BELONG, is the PISA sense-of-belonging weighted likelihood estimate. It uses six ST034 statements: feeling like an outsider, making friends easily, feeling that one belongs, feeling awkward and out of place, being liked by other students, and feeling lonely. Negatively worded items are reverse-coded in the OECD scaling so higher values consistently indicate stronger belonging. In 2022, each student was randomly assigned five of the six items under within-construct matrix sampling; a non-administered item is design missing, not ordinary item nonresponse. OECD linked the 2022 scale to the 2018 BELONG

metric (OECD, 2024). We use the supplied WLE and do not require complete responses to all six items. The scale is centred against an OECD reference distribution rather than bounded like a single Likert item.

The focal predictor, IMMIG, is the OECD-derived immigrant-background category: 1 = native, 2 = second generation, and 3 = first generation. The technical report specifies that a native student has at least one parent born in the country or economy of assessment; the student need not personally have been born there. Second-generation students were born in the assessment system and have parents born elsewhere; first-generation students and their parents were born elsewhere. The category is missing if the student's birthplace or both parents' birthplaces are unavailable. Thus “immigrant background” always means as defined by PISA. It is neither citizenship nor legal immigration status, ethnicity, or national identity. Native students are the regression reference group.

The adjusted model includes ST004D01T (standardized student sex; 1 = female, 2 = male), AGE (student age in years), and ESCS (index of economic, social and cultural status). The questionnaire asks whether the student is female or male, so the binary item should not be read as a measure of gender identity. An extended model adds ST022Q01TA: whether the language spoken at home most of the time is the language of the test (1) or another language (2). This official item has a consistent relative coding across the three samples, making a within-system comparison possible. “Other language” need not refer to the same language, level of proficiency, or degree of linguistic distance across systems; coefficients for this item should not be interpreted as a standardized language barrier. SPSS user-missing ranges were converted to missing values before analysis; the exact ranges and labels are documented in the variable dictionary.

3.3. Survey design and inference

All descriptive means, percentages, and regression coefficients use the final student weight W_FSTUWT. Sampling variance uses W_FSTURWT1 through W_FSTURWT80, following the PISA 2022 Technical Report’s Fay-modified balanced repeated replication method with Fay parameter 0.5 (OECD, 2024). For an estimate θ, the variance is $0.05 \times \Sigma_{r=1}^{80} (\theta_r - \theta)^2$. Each regression and reported BRR mean or proportion is recomputed with each replicate weight. Table 1 provides Fay-BRR standard errors for weighted generation shares and BELONG means; their 95% intervals are supplied in tables/Table 1_Descriptive.csv. Other descriptive SDs and covariate means are point estimates only. Two-sided p-values and 95% confidence intervals use normal approximations. Design-based sampling errors do not remove nonresponse, measurement, or model uncertainty.

Table 1
Sample characteristics and school belonging by system and immigrant generation

System	Generation	N	Wt % (SE)	BELONG M (SE)	SD	ESCS M	Age M	Male %	Other lang %
Hong Kong	Native	3,159	60.4 (1.3)	-0.383 (0.013)	0.720	-0.229	15.81	51.7	4.3
Hong Kong	Second generation	1,617	31.4 (1.1)	-0.392 (0.018)	0.659	-0.802	15.80	50.9	22.8
Hong Kong	First generation	379	8.2 (0.6)	-0.309 (0.041)	0.750	-0.678	15.84	55.5	64.7
Singapore	Native	4,596	71.5 (0.7)	-0.245 (0.013)	0.846	0.226	15.78	50.6	27.6
Singapore	Second generation	700	11.1 (0.4)	-0.144 (0.037)	0.935	0.485	15.76	51.3	55.4
Singapore	First generation	1,061	17.4 (0.7)	-0.170 (0.026)	0.853	0.558	15.77	51.2	69.0
Macao	Native	1,665	39.7 (0.7)	-0.335 (0.018)	0.703	-0.236	15.80	51.0	26.2
Macao	Second generation	1,604	38.3 (0.8)	-0.305 (0.017)	0.716	-0.525	15.80	51.1	16.4
Macao	First generation	914	22.0 (0.6)	-0.264 (0.029)	0.802	-0.654	15.81	50.7	9.3

Note. Values are weighted except N. Parentheses show Fay-BRR SEs for generation shares and BELONG means only; other descriptive values are point estimates. Other lang = home language differs from the test language.

3.4. Analytical strategy

Table 1 gives generation-specific weighted descriptive statistics. For each education system, Model 1 regresses BELONG on indicators for second and first generation; Model 2 adds sex, age, and ESCS; Model 3 adds the home-language indicator. All models use the same system-specific complete-case sample, so coefficient movement between Models 2 and 3 is not due to a change in cases. We report coefficient estimates rather than standardized “effects,” because immigrant generation is an observational category. Weighted R^2 is descriptive; formal uncertainty is based on the replicate weights.

For cross-system comparison, we form pairwise differences between the two generation coefficients estimated separately in each system. Their uncertainty combines system-specific replicate covariance estimates, treating the three PISA system samples as independent. A four-degree-of-freedom Wald test jointly examines equality of both generation contrasts across the systems. Within each system, we also directly contrast first- and second-generation coefficients using their full replicate covariance. Figure 1 displays Model 2 coefficients relative to native students. Adjusted predicted levels, with covariates fixed

at each system's own weighted means and re-estimated under every replicate, are shown only in Appendix Figure A1; they are not a system ranking. This approach avoids an unverified normalization of pooled cross-system weights.

The primary inferential family consists of the six Model 2 generation-versus-native comparisons across the three systems. We report unadjusted two-sided p-values and, as a transparent multiplicity supplement, Holm-adjusted p-values for this fixed family. No prospective registration or time-stamped analysis plan is claimed. Additional sensitivity analyses refit Model 2 without the language-item restriction and collapse the two immigrant generations. We also perform a limited reweighting check for analytic inclusion using sex and age, which are observed for all sampled students. A second, theory-led version adds GRADE, the official derived grade relative to the system's modal grade, coded as below-modal versus modal-or-above. Grade placement may relate to school adjustment and survey completion; it is fully observed in these three systems. We did not add parental education, occupation or home-possession measures to the response model because they are themselves missing for many excluded Hong Kong students. Both response models and their outcome regressions are re-estimated under every Fay replicate. They assume inclusion is independent of the unobserved outcome and immigrant category conditional on the respective predictors, a strong, unverified assumption; neither is a correction for all missingness.

The item sensitivity separates sample restriction from measurement. Step A fits BELONG Model 2 on the original common complete-case sample. Step B refits the same index model among those A students with a valid response to ST034Q03TA. Step C fits Model 2 with 5 − ST034Q03TA on exactly the same student IDs and weights as B. All steps use the final weight and 80 replicate weights. A versus B describes changes associated with item-response restriction; B versus C describes two measures in one sample. Because the WLE and single item have different units, coefficient magnitudes cannot be read as directly comparable effects. Differences in confidence-interval overlap or significance do not test equality of two outcomes or measurement invariance. The 2022 five-of-six-item matrix design means an unadministered item is not ordinary nonresponse; no six-item-completion rule is imposed. No gender interaction or bullying covariate is introduced; the latter would change this study's research question.

ChatGPT and Codex (OpenAI) assisted with the development and revision of analysis and plotting code. Statistical estimates and figures were generated by executing reproducible scripts on the PISA 2022 data; AI-generated text was not used as research data.

4. Results

4.1. Descriptive results

The weighted native, second-generation, and first-generation shares are 60.4%, 31.4%, and 8.2% in Hong Kong; 71.5%, 11.1%, and 17.4% in Singapore; and 39.7%, 38.3%, and 22.0% in Macao (Table 1). The composition of the PISA-defined groups differs substantially across the systems. Unadjusted weighted

BELONG means for native, second-generation, and first-generation students are − 0.383, − 0.392, and − 0.309 in Hong Kong; −0.245, − 0.144, and − 0.170 in Singapore; and − 0.335, − 0.305, and − 0.264 in Macao. The descriptive pattern does not show a uniform native-student advantage across these samples. Keeping three categories preserves descriptive information that a binary immigrant indicator would discard; the direct tests below do not establish a difference between the two immigrant generations.

4.2. Unadjusted differences

In Hong Kong, the Model 1 second-generation contrast is close to zero (b = − 0.009, 95% CI [− 0.053, 0.036]); the first-generation contrast is positive but its interval includes zero (b = 0.074, 95% CI [− 0.014, 0.163]). In Singapore, both contrasts are positive: 0.100 for second-generation students (95% CI [0.026, 0.174]) and 0.075 for first-generation students (95% CI [0.020, 0.129]). In Macao, the second-generation contrast is 0.030 (95% CI [− 0.020, 0.079]), whereas the first-generation contrast is 0.071 (95% CI [0.007, 0.135]). Table 2 summarizes the generation contrasts and design-based standard errors; its accompanying CSV contains all control coefficients.

Table 2
Immigrant-generation coefficients from survey-weighted regression models

System	Model	Contrast	b	BRR SE	95% CI	p	N
Hong Kong	M1	Second generation	-0.009	0.023	[-0.053, 0.036]	0.699	5,155
Hong Kong	M1	First generation	0.074	0.045	[-0.014, 0.163]	0.100	5,155
Hong Kong	M2	Second generation	0.023	0.025	[-0.025, 0.071]	0.347	5,155
Hong Kong	M2	First generation	0.100	0.046	[0.009, 0.190]	0.031	5,155
Hong Kong	M3	Second generation	0.030	0.025	[-0.019, 0.080]	0.231	5,155
Hong Kong	M3	First generation	0.125	0.050	[0.027, 0.223]	0.013	5,155
Singapore	M1	Second generation	0.100	0.038	[0.026, 0.174]	0.008	6,357
Singapore	M1	First generation	0.075	0.028	[0.020, 0.129]	0.008	6,357
Singapore	M2	Second generation	0.082	0.038	[0.008, 0.155]	0.030	6,357
Singapore	M2	First generation	0.052	0.028	[-0.002, 0.107]	0.058	6,357
Singapore	M3	Second generation	0.076	0.039	[-0.001, 0.153]	0.054	6,357
Singapore	M3	First generation	0.044	0.028	[-0.012, 0.100]	0.122	6,357
Macao	M1	Second generation	0.030	0.025	[-0.020, 0.079]	0.242	4,183
Macao	M1	First generation	0.071	0.033	[0.007, 0.135]	0.030	4,183
Macao	M2	Second generation	0.041	0.025	[-0.007, 0.089]	0.092	4,183

Note. Native students are the reference group. M1: generation only; M2: plus sex, age and ESCS; M3: plus home-versus-test language. All models use the same complete-case sample within system. Supplementary Table S1 reports every coefficient and weighted R^2. Macao M3 first-generation CI and p are shown to extra precision because they straddle the .05 threshold. SEs use 80 Fay-BRR replicates, factor 0.05.

System	Model	Contrast	b	BRR SE	95% CI	p	N
Macao	M2	First generation	0.089	0.033	[0.025, 0.153]	0.007	4,183
Macao	M3	Second generation	0.029	0.025	[-0.019, 0.077]	0.242	4,183
Macao	M3	First generation	0.065	0.033	[-0.00007, 0.13070]	0.05023	4,183

Note. Native students are the reference group. M1: generation only; M2: plus sex, age and ESCS; M3: plus home-versus-test language. All models use the same complete-case sample within system. Supplementary Table S1 reports every coefficient and weighted R^2. Macao M3 first-generation CI and p are shown to extra precision because they straddle the .05 threshold. SEs use 80 Fay-BRR replicates, factor 0.05.

4.3. Adjusted models

In Hong Kong (Model 2; N = 5,155), the first-generation contrast with native students is b = 0.100 (BRR SE = 0.046, 95% CI [0.009, 0.190], raw p = .031, Holm p = .149); the second-generation contrast is b = 0.023 (SE = 0.025, 95% CI [− 0.025, 0.071], raw p = .347, Holm p = .347). In Singapore (Model 2; N = 6,357), the second-generation contrast is b = 0.082 (SE = 0.038, 95% CI [0.008, 0.155], raw p = .030, Holm p = .149); the first-generation contrast is b = 0.052 (SE = 0.028, 95% CI [− 0.002, 0.107], raw p = .058, Holm p = .175). In Macao (Model 2; N = 4,183), the first-generation contrast is b = 0.089 (SE = 0.033, 95% CI [0.025, 0.153], raw p = .007, Holm p = .040); the second-generation contrast is b = 0.041 (SE = 0.025, 95% CI [− 0.007, 0.089], raw p = .092, Holm p = .185). These contrasts are small relative to within-group SDs, and weighted model R^2 is approximately .008–.010. The Holm supplement leaves only Macao's first-generation-versus-native comparison below .05; it does not change the coefficients or their unadjusted intervals.

Adding the home-language item in Model 3 changes the generation coefficients. The first-generation estimate is 0.125 in Hong Kong (95% CI [0.027, 0.223]); Singapore's second-generation estimate is 0.076 (95% CI [− 0.001, 0.153]); Macao's first-generation estimate is 0.06532 (95% CI [− 0.00007, 0.13070], raw p = .05023). The extra precision in the Macao result is intentional: its interval extends slightly below zero and its p-value is slightly above .05. The home-versus-test-language coefficient is − 0.041 in Hong Kong (95% CI [− 0.098, 0.015]), 0.018 in Singapore (95% CI [− 0.029, 0.065]), and − 0.186 in Macao (95% CI [− 0.228, − 0.144]). The Macao association concerns this relative language indicator, not language proficiency or a uniform language barrier. Coefficient movement after adjustment is not evidence of mediation. Full coefficients, controls, and model information appear in Supplementary Table S1.

4.4. Cross-system heterogeneity and adjusted predictions

The three systems' point estimates are not identical, but the Model 2 joint test does not reject equality of the two generation contrasts across systems (Wald $\chi^2(4) = 3.475$, p = .482). None of the six pairwise coefficient differences has a 95% interval excluding zero (Table 3). The Model 3 joint test is similar

($\chi^2(4) = 4.066$, $p = .397$). These tests neither demonstrate cross-system heterogeneity nor prove equivalence. Figure 1 therefore shows within-system coefficients and intervals relative to native students, without implying a ranking of the systems.

Table 3
Cross-system contrasts in adjusted immigrant-generation associations

Model	Contrast	Term	Difference / χ^2	95% CI	p
M2	HK minus SG	Second generation	-0.059	[-0.147, 0.029]	0.192
M2	HK minus SG	First generation	0.047	[-0.058, 0.153]	0.378
M2	HK minus MO	Second generation	-0.018	[-0.086, 0.050]	0.599
M2	HK minus MO	First generation	0.011	[-0.100, 0.122]	0.843
M2	SG minus MO	Second generation	0.040	[-0.048, 0.128]	0.369
M2	SG minus MO	First generation	-0.036	[-0.120, 0.048]	0.398
M2	Omnibus $\chi^2(4)$	Both generations	3.475		0.482
M3	HK minus SG	Second generation	-0.045	[-0.137, 0.046]	0.332
M3	HK minus SG	First generation	0.081	[-0.032, 0.193]	0.161
M3	HK minus MO	Second generation	0.002	[-0.067, 0.071]	0.960
M3	HK minus MO	First generation	0.059	[-0.059, 0.177]	0.324
M3	SG minus MO	Second generation	0.047	[-0.044, 0.138]	0.309
M3	SG minus MO	First generation	-0.021	[-0.107, 0.065]	0.627
M3	Omnibus $\chi^2(4)$	Both generations	4.066		0.397

Note. The omnibus Wald test has 4 degrees of freedom. Variances combine independent system-specific Fay-BRR covariance estimates.

The direct Model 2 first-minus-second-generation contrast is 0.07681 in Hong Kong (95% CI [− 0.00998, 0.16360], p = .08280), − 0.02920 in Singapore ([− 0.11468, 0.05627], p = .50305), and 0.04738 in Macao ([− 0.02343, 0.11818], p = .18969). Each variance uses the within-system covariance of the two coefficients from all 80 replicates. None of these intervals excludes zero (Table 4). The three-category coding remains substantively useful, but these data do not establish a first-versus-second-generation difference within any of the systems. Appendix Figure A1 retains adjusted predicted levels at each system's own weighted covariate means; the figure is not used to rank systems.

Table 4
Direct first-minus-second-generation contrasts within systems, Model 2

System	Difference	BRR SE	95% CI	p	N
Hong Kong	0.07681	0.04428	[-0.00998, 0.16360]	0.08280	5,155
Singapore	-0.02920	0.04361	[-0.11468, 0.05627]	0.50305	6,357
Macao	0.04738	0.03612	[-0.02343, 0.11818]	0.18969	4,183

Note. The replicate variance of each difference includes covariance between the two generation coefficients.

Table 5
Six Model 2 generation-versus-native comparisons with Holm adjustment

System	Contrast	b	Raw p	Holm p
Macao	First generation	0.089	0.007	0.040
Singapore	Second generation	0.082	0.030	0.149
Hong Kong	First generation	0.100	0.031	0.149
Singapore	First generation	0.052	0.058	0.175
Macao	Second generation	0.041	0.092	0.185
Hong Kong	Second generation	0.023	0.347	0.347

Note. The six M2 comparisons form one fixed family; Holm p-values do not alter coefficients or unadjusted confidence intervals.

4.5. Analytic missingness

The final Hong Kong sample excludes 12.73% of raw records; the weighted exclusion proportion is 13.01% (95% BRR CI [11.72%, 14.30%]). Raw IMMIG is missing for 708 Hong Kong students, or 12.21% after weighting. Missingness overlaps: 398 Hong Kong records lack IMMIG alone among the six analysis variables, while 256 lack BELONG, IMMIG, ESCS, and the language item together. Among students whose BELONG is observed, the weighted mean is − 0.380 for included cases and − 0.472 for excluded cases. The corresponding observed ESCS means are − 0.446 and − 0.645, and males comprise 51.8% and 62.4%, respectively. These comparisons indicate analytic selection on observed characteristics; they cannot reveal the missing BELONG or IMMIG values. Weighted complete-case proportions are 96.26% in Singapore and 95.43% in Macao. Variable-specific missingness, overlapping patterns, and BRR uncertainty for diagnostic proportions are reported in the reproducibility files. This issue is distinct from OECD's Hong Kong survey-response-rate concern.

4.6. Sensitivity analyses

Removing the home-language requirement changes the analysis sample only slightly and does little to address missing BELONG or IMMIG. The sex-and-age response-propensity check and its grade-

augmented counterpart produce focal generation estimates close to Model 2. Both refit the selection model in each Fay-BRR replicate. They address selection only if inclusion is conditionally independent of the missing analysis values given their observed predictors; grade is a coarse placement measure, so that assumption remains uncertain. Supplementary Table S3A reports the probability ranges, inverse-probability multipliers, and estimates by system. Collapsing immigrant generations reduces descriptive detail, while the direct generation contrasts do not establish statistically distinct associations.

The matched measurement check has three stages (Supplementary Table S2): A uses BELONG on the common complete-case sample; B uses BELONG on the subset that answered ST034Q03TA; C uses the recoded direct item on exactly the same students as B. Student IDs, record order, and all analysis weights match between B and C. Supplementary Table S3B records the stage sample sizes and explains why an earlier wider-inclusion item check contained a few more students.

The Hong Kong first-generation coefficient is 0.100 in A, 0.117 in B, and 0.082 in C; the corresponding second-generation values are 0.023, 0.031, and 0.079. The full estimates and intervals for all systems appear in Supplementary Table S2. A versus B shows the effect of restricting the sample while retaining the index; B versus C compares measures on identical students. Valid ST034Q03TA responses are 1–4; after recoding as 5 − ST034Q03TA, the four-point direct item runs from 1 (lowest) to 4 (highest) belonging agreement. The WLE and direct item have different units, so coefficient magnitudes cannot establish a stronger or weaker association. Different significance labels neither test equality of results nor demonstrate measurement non-equivalence. Design-unadministered item responses are not treated as ordinary nonresponse.

5. Discussion

5.1. Immigrant generation and subjective school membership

The adjusted associations are small and do not show a general pattern of lower belonging among immigrant-background adolescents. After accounting for the family of primary comparisons, only the first-generation contrast in Macao remains statistically significant. The direct comparisons between the two immigrant generations are inconclusive in every system. These findings offer limited evidence for treating generation categories as distinct levels of psychological membership, even though retaining them preserves useful descriptive information.

From a need-to-belong perspective, group comparisons concern reported membership in a setting where adolescents form social relationships. The small average contrasts caution against inferring an individual adolescent's belonging from immigrant-generation membership alone. This is an interpretive caution about group averages, not an assessment of individual predictive accuracy. The models do not measure the availability or quality of interpersonal bonds and therefore do not test belongingness theory directly.

5.2. Acculturation and the limits of a deficit account

The positive Hong Kong first-generation estimate is compatible with earlier local findings that did not show a straightforward immigrant belonging deficit (Cheung & Hui, 2003; Ni & Han, 2022). Its direction differs from the average native advantage reported in the broader comparison by Chiu et al. (2012), although differences in samples and measures preclude treating these studies as direct replications. The Hong Kong finding is also less conclusive after multiplicity adjustment.

Acculturation provides possible interpretations of such patterns, not an observed explanation. Family migration histories may coincide with disruptions, new social opportunities, or differing expectations of school. The present data cannot distinguish among those accounts. Research that measures acculturation orientations or a broader range of belonging influences addresses dimensions that birthplace categories leave unresolved (Schachner et al., 2017; Jain et al., 2026). Consequently, a small positive group association should not be labelled successful acculturation, resilience, or psychological protection.

The direct generation tests are particularly relevant here. Being locally born to parents born elsewhere does not, by itself, establish a belonging advantage over having been born elsewhere. The current intervals leave that comparison uncertain. They therefore do not support a simple generational progression toward greater membership, while also lacking the precision and design required to rule out such a pattern under more specific conditions.

5.3. What the contextual comparison establishes

The cross-system tests do not establish heterogeneity in the adjusted generation associations. This result does not demonstrate equivalence. Differences in population composition, measurement properties, and unobserved experiences remain relevant when interpreting the uncertainty around the contrasts.

The joint comparison evaluates whether the estimated generation associations differ across these settings. Explanations invoking different climates of reception additionally require measures of the experiences proposed to shape belonging. Studies of school climate and intercultural values address some of those experiences directly (Choi et al., 2025; Ordóñez-Carabaño et al., 2025). The present estimates provide a comparative reference for that work without attributing the observed associations to a cultural or institutional mechanism.

The language adjustment illustrates the same distinction. The negative home-versus-test-language association in Macao concerns a relative language indicator. It does not measure proficiency, acculturative stress, or cultural distance, and its substantive meaning differs across systems. Changes in generation coefficients after this adjustment cannot establish mediation. Understanding the psychological role of language would require information about students' communication experiences, the languages used in relevant relationships, and how those experiences relate to acceptance at school.

5.4. Implications for adolescent belonging research and practice

For research, the findings favour more precise links between demographic descriptors and psychological constructs. Immigrant generation can organise comparisons, but accounts of adolescent adjustment need measures of the experiences proposed to connect migration histories with belonging. Longitudinal evidence on relationships, school transitions, and perceived inclusion would help distinguish those accounts. The current results supply a comparative reference for such work without selecting one mechanism as the explanation.

For practice, the group comparisons should be considered alongside students' own reports of membership and experiences of acceptance. They do not evaluate a screening tool or a support programme, and they provide no basis for ranking systems by the effectiveness of their support for immigrant adolescents.

5.5. Limitations

The cross-sectional design cannot identify a causal effect of migration background on belonging or trace within-person adjustment. Unobserved differences in family circumstances, prior experiences, school placement, or relationships may account for part of the associations. The secondary data were not designed to test the psychological processes developed in this interpretation. Acculturation orientations, relational security, perceived discrimination, and cultural identification are not modelled, so they remain possible directions for explanation rather than established mechanisms.

Belonging is self-reported and may be affected by differences in interpretation, expectations, or response styles. The PISA index captures a specific aspect of school experience; it is not a comprehensive measure of mental health, social integration, or adolescent adjustment. We did not establish item-level measurement invariance across systems or generations. The matched single-item analysis separates sample restriction from measure choice but does not resolve comparability. These construct limitations constrain both group comparisons and the psychological meaning attributed to them.

PISA's birthplace-based categories combine diverse origins and do not identify citizenship, legal status, ethnicity, age at arrival, or time in the receiving system. Its native category includes students with at least one locally born parent even if the student was born elsewhere. Cross-border mobility involving Hong Kong and Macao therefore need not correspond to conventional accounts of international migration. The home-language indicator likewise represents different substantive language contrasts across settings.

Complete-case selection is substantial in Hong Kong, and included and excluded students differ on observed characteristics. The response-propensity checks depend on limited conditional assumptions; neither recovers missing immigrant classifications nor establishes that missingness is random. Survey weights account for the original sampling design, not automatically for additional analytic selection.

Separately, OECD identifies Hong Kong as not meeting one or more sampling standards and states that more than minimal bias cannot be ruled out (OECD, 2023). Discussion of possible achievement bias cannot determine the direction of bias in belonging. Finally, these systems are not a random sample of East Asia, and inconclusive heterogeneity tests do not establish equivalence. The conclusions remain specific to the measured associations and their uncertainty.

6. Conclusion

Using the same PISA cycle, this study extends evidence on school belonging across Hong Kong, Singapore, and Macao by estimating the size and precision of immigrant-generation associations and directly comparing generations and systems. The adjusted associations are small. Direct first-versus-second-generation and joint cross-system comparisons remain inconclusive. These findings provide empirical constraints for interpreting group differences in adolescent belonging, while the underlying relational and acculturative processes remain untested.

Declarations

Ethics and participant contact

This study analysed de-identified records from the OECD PISA 2022 public-use dataset. No participants were recruited or contacted for this secondary analysis.

Data and code availability

The study used the OECD PISA 2022 Student Questionnaire Public Use File. Analysis code and reproducibility materials are retained in a project archive. No public code repository has yet been established. Student-level data are not included in the submission materials.

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Declaration of competing interests

The author declares no financial or non-financial competing interests relevant to this work.

Declaration of generative AI and AI-assisted technologies in the manuscript preparation process

OpenAI ChatGPT and Codex were used to assist with manuscript drafting and language editing, development and checking of analysis code, figure-generation code, and literature and reference organisation. The author reviewed and edited the earlier manuscript and checked its research question and methods, main and supplementary tables, figures, key references, conclusions and limitations. AI assistance was also used to revise the framing and language for this version. The specific model versions could not be confirmed from the available project records.

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Figures

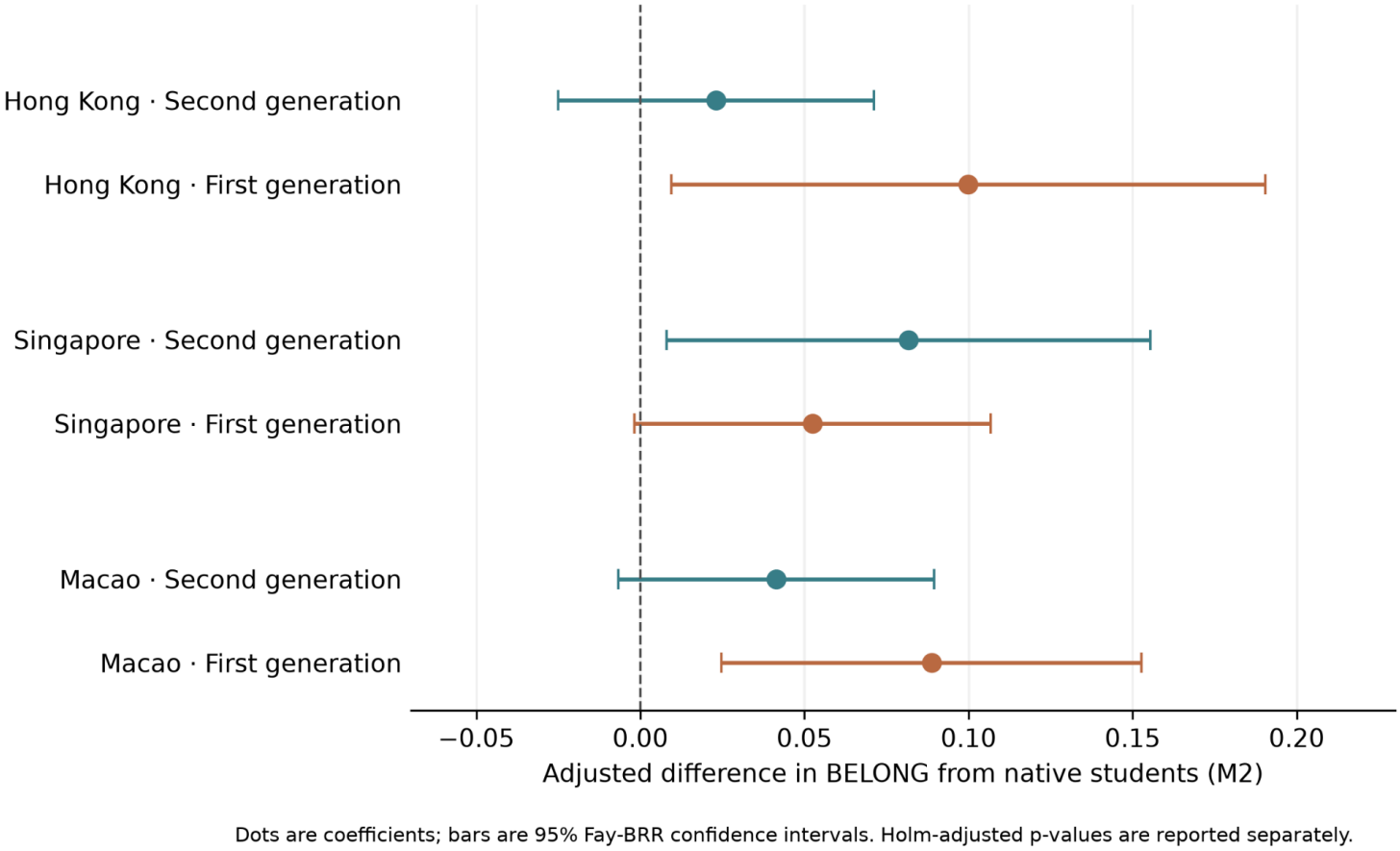


Figure 1

Model 2 immigrant-generation contrasts relative to native students

Note. Dots are coefficients; bars are 95% Fay-BRR confidence intervals. Cross-system coefficient differences are tested in Table 3.

Supplementary Files

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