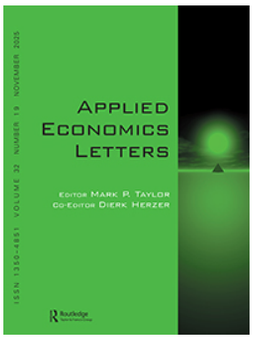

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Beyond academic achievement: class size and distress in early school years

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ABSTRACT

Although the effects of class size have long attracted academic and public attention, causal research has focused primarily on cognitive outcomes, potentially underestimating the broader effects on students. Using data from Danish primary schools, this study documents that larger classes in grades K-2 significantly increase students' self-reported physical and emotional distress, with effects concentrated among students from low-income families. These results highlight the socioemotional consequences of class size and underscore the importance of considering student well-being alongside academic outcomes when evaluating and designing class-size policies.

KEYWORDS

School resources; class size; student well-being; distress; student–teacher ratio

JEL CLASSIFICATION

I21; I28; J24

I. Introduction

Many professionals, policymakers, and parents regard class size as central to children's educational environment, although critics argue that smaller classes are a costly and inflexible strategy for improving the student–teacher ratio compared to alternatives like co-educators (Andersen et al. 2020). However, a unilateral focus on academic achievement may underestimate the benefits of smaller classes. In addition to reduced individualized teacher attention and fewer opportunities for participation, larger classes may increase social complexity, peer conflict, and exposure to noise and disruptions (Dee and West 2011; Lazear 2001; Shield and Dockrell 2003), which may further sow the seeds for adverse attendance trajectories (Tran and Gershenson 2021). While additional staff can improve student-teacher ratios and help equalize teacher attention and participation opportunities, they may not offset the broader set of stressors in larger classes.

This paper considers the effect of class size on self-reported physical and emotional distress in school – a key aspect of student well-being linked to coping with school-environment stressors. Evidence on class-size effects beyond academic outcomes is limited, mostly concerning noncognitive skills such as effort, initiative, and emotional maturity (Chetty et al. 2011; Connolly and Haeck 2022; Dee and West 2011; Fredriksson, Öckert, and Oosterbeek 2013).[1] Related work shows that parental investments likely substitute for school resources (Fredriksson, Öckert, and Oosterbeek 2016), potentially explaining why negative class-size effects on skill accumulation are often most pronounced for low-income children (Angrist and Lavy 1999; Connolly and Haeck 2022). However, while (high-ability) parents can compensate for limited teacher attention by providing academic or emotional support at home (Fredriksson, Öckert, and Oosterbeek 2016), they may be less able to buffer classroom-level stressors such as noise or peer dynamics, warranting an exploration of class-size effects on distress across student socioeconomic background.

We document significant adverse effects of class size on distress among students in introductory schooling (grades K-2), concentrated among those from low-income families. We focus on early schooling, because, theoretically, early-life influences and the capacity to cope with stressors accumulate over time (Ben-Shlomo and Kuh 2002; Cunha, Heckman, and Schennach 2010), and empirically, identification is less likely to be compromised by manipulation of grade enrolment or classroom and teacher assignments.

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[1]Exceptions are wellbeing and mental health (Jakobsson, Persson, and Svensson 2013) and school attendance (Tran and Gershenson 2021). Fredriksson, Öckert, and Oosterbeek (2013) studies a noncognitive index including anxiety and absenteeism.

Table 1. Sample description.

	Mean	SD
Total school size, year before grade K	569.23	221.84
Average class size, grades K-2	22.94	4.57
Grade K enrollment	61.91	25.98
Distress score	1.52	0.39
Observations	135,197	

Notes. See text for sampling strategy. Distress scores are calculated as the average self-reported score on the six items loading on distress on a scale from 1–3, where 3 is most negative response.

II. Materials and methods

From the national administrative registers, we sample all students enrolling in grade K in Danish public schools during the 2014/2015 through 2016/2017 academic years, and follow them until grade 2. We exclude very small (<7 students) and very large grade K cohorts (>140 students) (totalling 0.8% of school cohorts).

Using personal identifiers, we add register-based student demographics. Self-reported physical and emotional distress scores in grade 2 are obtained from the Danish Student Well-being Survey (DSWS), conducted annually in public schools. For the introductory years, the DSWS contains 20 items rated on a Likert scale from 1 to 3 (3 denotes the most positive response, reverse-coded here). From this a factor loading on physical and emotional distress is derived (Damm et al. 2021).[2] Methodological concerns about this measure are discussed in Appendix A. We standardize student distress to mean 0 and standard deviation 1. Tables 1 and B1 describe the sample.

Method

A government-imposed class size cap on 28 students in Danish public schools creates discontinuities in the expected class size at multiples of 28: two schools with small differences in grade K enrolment have different number of classes and, thus, variation in expected class size just above versus just below thresholds. This source of exogenous variation has been widely used in the class size literature (see seminal study by Angrist and Lavy (1999)). Following Fredriksson, Öckert, and Oosterbeek (2013), we estimate the effect of a one-student increase in the average class size across grades K-2, using enrolment cohort size in grade K as instrument. We use beginning-of-the-school year enrolment to reduce the risk of anticipation and manipulation by parents and administrators.

Omitting a subscript for cohort year, the empirical model reads:

$$y_{ijkm} = \beta_0 + \beta_1 AvgCS_{jkm} + X_{ik}\beta_2 + \lambda_m + \varepsilon_{ijkm}, \quad (1)$$

where y_{ijkm} is the distress level in grade 2 of student i in class j in school k, $AvgCS_{jk}$ is the average class size in grades K-2. X_{ik} is a vector of student and school-specific characteristics, which includes a second-order polynomial in grade K enrollment interacted with enrollment segments (fixed effects for nearest threshold) and a second order polynomial in school size to flexibly control for confounding factors of student outcomes related to school size. We include municipality fixed effects,λ_m, to overcome municipal-specific factors affecting both class size and student outcomes, e.g. budgetary conditions (schools are governed administratively and financially at the municipal level) and teachers' local labour market. Appendix Table B2 provides robustness for this specification choice.

We instrument average class size in grades K-2 by the predicted class size based on grade K enrolment and the 28-student cap, $Pred_{jk}$:

$$AvgCS_{jkm} = \delta_0 + \delta_1 PredCS_{jk} + X_{ik}\delta_2 + \lambda_m + \varepsilon_{ijkm} \quad (2)$$

We estimate Equations (1) and (2) using 2SLS and adjust standard errors to account for within-school correlation. Figure 1, Panel a illustrates the empirical first stage relation between average class size in grades K-2 and predicted class size based on grade K enrolment. Average class size clearly relates to the expected class size according to the 28-student cap, particularly for the lower thresholds. To assess whether grade K enrolment is systematically manipulated around thresholds, we regress predicted class size on student and school characteristics. From this, we cannot reject that student characteristics are jointly unrelated with

[2]The factor includes six items on feelings of loneliness, stomach- and headaches, being teased, being laughed at, and noise levels (see Appendix A).

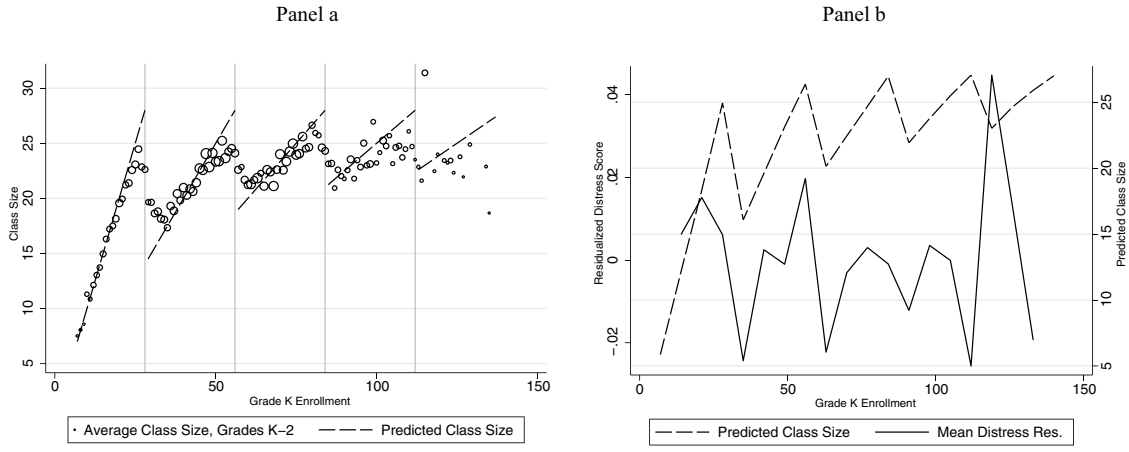

Figure 1. Class size and student distress by grade K enrollment. Panel A: markers are weighted by observation count at the classroom level. Panel B: residualized distress scores, controlling for student characteristics and fixed effects for municipality, year, and enrollment segment, and predicted class size are averaged within 7-student bins.

the instrument (F-statistic = 1.38, see Appendix Table B1).[3]

Figure 1, Panel b illustrates the reduced form relationship between class size as predicted by grade K enrolment and the 28-student cap and students' mean residualized distress score in grade 2 in enrolment bins of 7 students. Around the lower thresholds, residualized distress clearly mirrors the fluctuations of predicted class size, suggesting a plausible relationship between the two variables.

III. Results

Table 2, column (1) reports the first and second stage estimates from the model in Eq. (1) and (2). A one-student increase in predicted class size is associated with a 0.4 student increase in average class size across grades K-2. The reported Kleibergen-Paap F-statistic confirms a strong first stage in the expected direction, suggesting that the 95%-confidence intervals for the second stage estimates need not be adjusted (Angrist and Kolesár 2024).

The 2SLS estimate indicate that larger average class sizes in grades K-2 increase students' self-reported physical and emotional distress in grade 2 by 0.01 standard deviations per additional student.[4] While modest, this effect size align with findings for noncognitive outcomes in the literature using similar methodology (e.g. Connolly and Haeck 2022). In practical terms, a five-student class-size increase raises student distress by 0.022

Table 2. 2SLS-estimates of average class size on student distress in grade 2.

	(1)	(2)	(3)
		Parents' disposable income	
Sample	Full	1st quartile	2nd- 4th quartile
First stage: Predicted class size	0.405***	0.355***	0.421***
	(0.032)	(0.034)	(0.033)
Kleibergen-Paap F-statistic	164.113	106.388	166.206
Second stage:	0.011**	0.022**	0.008
Avg. Class Size, Grades K-2			
	(0.005)	(0.009)	(0.005)
Observations	123,836	27,065	96,771

Notes. Specifications control for student characteristics, indicators for imputed information on mothers and fathers, a second-order polynomial in school size, fixed effects for year and municipality, and a second-order polynomial for grade K enrolment size interacted with thresholds. Cluster-robust standard errors in parentheses, $^{**}p < 0.05$, $^{***}p < 0.01$.

[3]Formally, $PredCS_{jk} = \frac{e_{jk}}{int\left((e_{jk}-1)/28\right)+1}$, reflecting that a grade K cohort of 28 students forms a single class, whereas 29 students are split in two classes with expected 14.5 students in each (Angrist and Lavy 1999).

[4]Results are robust to restricting the sample to grade K cohorts within ± 5 students of thresholds (Appendix Table B2). This narrow window minimizes concerns that differences in school size or related factors drive the results, and makes it unlikely that parents or administrators could precisely anticipate and manipulate cohort size at enrolment.

points on the restricted, average 1–3 scale – not enough to register as a full response-category shift in the DSWS (~0.26 points across all six distress-score items). Though individually small, their cumulative impact across classrooms can amount to meaningful differences for schools.

Columns (2) and (3) of Table 2 indicate a more pronounced effect among students from low-income families although not statistically different ($p = 0.19$). This pattern mirrors the findings in the skill-accumulation literature (e.g. Connolly and Haeck 2022; Fredriksson, Öckert, and Oosterbeek 2016), underlining that low-income students are particularly vulnerable to larger classes. High-income parents may at least in part compensate for reduced teacher attention and other classroom-level stressors, while such compensation is less available to low-income families. Differences may also arise if teaching practices in larger classes disproportionately benefit more affluent children, amplifying distress for those already at disadvantage.

IV. Discussion

Though a focal outcome in school, a unilateral focus on academics may overlook important aspects of school life. We document that larger classes increase physical and emotional distress in early schooling, particularly among students from low-income families. Because students' socioemotional wellbeing is likely closely linked to both attendance and to noncognitive and cognitive skill accumulation, these effects may reinforce a negative impact of larger classes on academic achievement. Future research should disentangle these pathways to better guide the allocation of school resources. Our findings are specific to Danish primary schools with compensatory funding, catchment-based enrolment, and limited school segregation. In more stratified school systems, the social gradient in class-size effects on distress could be stronger. Effects may also differ at later educational stages as academic and social pressures shift and coping skills mature.

Our data predate the COVID-19 pandemic, which markedly reshaped learning environments; exploring whether class-size effects changed post-pandemic remains an important avenue for future work.

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Author contributions

CRediT: **Louise Beuchert:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing; **Anne Brink Nandrup:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project administration, Writing – original draft, Writing – review & editing.

Disclosure statement

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Appendices

Appendix A. Student distress in grade 2

Students' physical and emotional distress is measured as the average self-reported score across six items from the Danish Student Well-being Survey (DSWS) in early schooling: "Do you feel lonely in school?", "Does your stomach hurt in school?", "Do you have headaches in school?", "Is anyone teasing you and making you feel sad?", "Are you afraid that other children laugh at you in school?", and "Is it difficult to hear what the teachers say in class?". An exploratory factor analysis identified these items as loading on a single factor (Damm et al. 2021), with Cronbach's $\alpha = 0.68$.

Self-reported measures capture children's own experiences but may be affected by limited self-awareness, comprehension of emotions, and susceptibility to adult approval. To reduce survey complexity for young pupils, the DSWS uses a three-point Likert scale in grades K–3. While simplifying the task for the young respondees, the restricted scale limits variation and increases the risk of floor effects, i.e. reduced sensitivity to differences among pupils with low levels of distress. Such features may attenuate estimated effects of class size, biasing results toward the null.

To mitigate these concerns, we focus on grade 2 (age 8), when self-reports are more reliable compared to grades K and 1, and rely on the average across six items rather than single responses. This aggregation increases variation and reduces measurement error in single items, though some floor effects likely remain: 13.6% of pupils in the sample report the least possible score (most positive) on all six items loading on the distress factor (Appendix Figure A1).

Although more prone to attenuation bias than the composite distress score, for completeness, Appendix Table A1 shows the estimated effects of larger classes on each item separately. With the exception of feeling teased often, which is a precisely estimated zero, all point estimates are in the same direction, though only three are significantly positive on the 5% level.

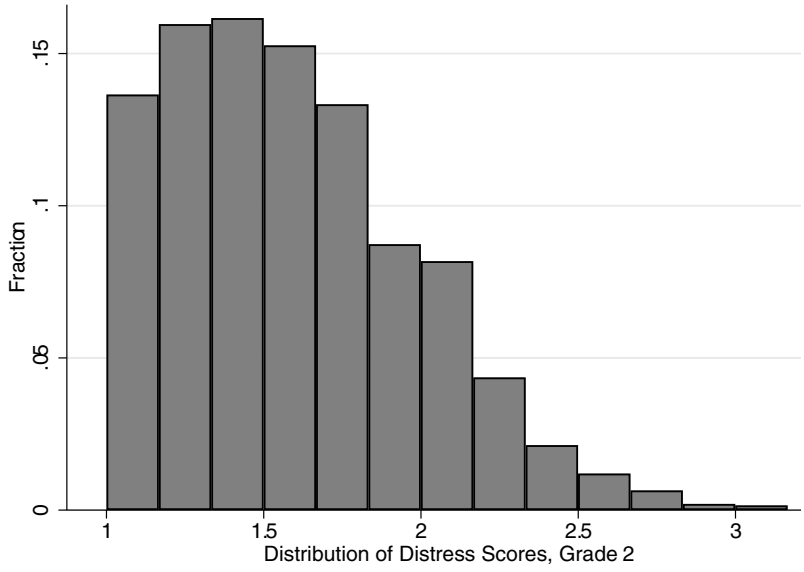

Figure A1. Distribution of distress scores in sample. *Notes*. The figure illustrates the sample distribution of average self-reported score on the six items loading on the distress factor, each item rated on a Likert scale from 1 to 3 (most negative).

Table A1. 2SLS-estimates of average class size on physical and emotional distress, by item.

	(1) Coeff.	(2) SE
Item		
Feels lonely (*N = 121,422*)	0.002	(0.002)
Stomach ache (*N = 122,176*)	0.006**	(0.003)
Headache (*N = 122,987*)	0.007**	(0.003)
Often teased (*N = 118,624*)	−0.000	(0.003)
Afraid of being laughed at (*N = 119,448*)	0.006**	(0.003)
Difficulties hearing the teacher (*N = 123,116*)	0.004	(0.003)

Notes. Average class size in grades K-2 is instrumented by predicted class size based on grade K enrolment. See Table note 2 for specification details. Items rated on a Likert scale from 1–3 (most negative). Cluster-robust standard errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Appendix B. Additional tables

Table B1. Sample description, student characteristics.

	Full sample	
Student characteristics	Mean	SD
Boy	0.51	0.50
Immigrant or descendent	0.10	0.30
Not nuclear family	0.20	0.40
Mother's age at birth	30.75	4.97
Mother's high educ: high school or less	0.20	0.40
—vocational	0.30	0.46
—tertiary	0.50	0.50
Mother's disposable income (DKK, log)	12.35	0.49
Father's high educ: high school or less	0.22	0.41
—vocational	0.39	0.49
—tertiary	0.39	0.49
Father's disposable income (DKK, log)	12.46	0.59
Missing in registers	0.01	0.07
First born	0.45	0.50
Number of siblings younger than 6 yrs.	0.50	0.60
Delayed school start	0.06	0.24
Born in December	0.08	0.27
Born in January	0.08	0.28
Observations	135,197	
F-test for joint significance of student characteristics for instrument	1.38 ($p = 0.15$)	

Notes. See text for sampling strategy. OLS regression for relevance of student characteristics for instrument further includes indicators for imputed information on mothers and fathers, a second-order polynomial in school size, and fixed effects for year, municipality, and enrolment segment.

Table B2. Robustness: 2SLS-estimates of average class size on student distress in grade 2.

	(1)	(2)	(3)
Specification	Main	Full sample School FE	Grade K enrolment size ±5 students around thresholds
First stage: Predicted class size	0.405***	0.402***	0.319***
	(0.032)	(0.032)	(0.037)
Kleibergen-Paap *F*-statistic	164.113	156.022	75.491
Second stage:	0.011**	0.013**	0.016**
Avg. Class Size, Grades K-2			
	(0.005)	(0.006)	(0.008)
Observations	123,836	123,832	37,917
Adjusted R^2	0.035	0.032	0.033
Municipal FE	Yes	No	Yes
School FE	No	Yes	No

Notes. Specifications control for student characteristics, indicators for imputed information on mothers and fathers, a second-order polynomial in school size, and fixed effects for year. Full sample specifications in column (1) and (2) further control for a second order polynomial in grade K enrolment size interacted with thresholds. Columns (1, main specification) and (3) further controls for municipality fixed effects. Column (2) controls for school fixed effects. Cluster-robust standard errors in parentheses, ** $p < 0.05$, *** $p < 0.01$.

Table B3. 2SLS-estimates of average class size on student distress in grade 2, functional form.

Specifications	(1) 1st threshold (Grade K enrollment: 7 to 56 students)	(2) 2nd and 3rd threshold (Grade K enrollment: 29 to 98 students)	(3) Second order polynomial in avg. class size	(4) Breakpoint (t): Avg. class size = 19	(5) Breakpoint (t): Avg. class size = 21	(6) Breakpoint (t): Avg. class size = school average class size
Average Class Size, grades 0–2 (CS)	0.011*	0.014*	0.092	0.017	0.013	0.002
	(0.006)	(0.009)	(0.340)	(0.016)	(0.010)	(0.003)
Avg. Class Size, Squared (CS^2)			−0.002			
			(0.008)			
Avg. Class Size, above t ($CS - t$)				−0.007	−0.004	0.021*
				(0.020)	(0.016)	(0.011)
Observations	57,210	104,626	123,836	123,836	123,836	123,836
Adjusted R^2	0.030	0.033	0.022	0.034	0.034	0.031
Kleibergen-Paap F-statistic	154.818	78.201	0.050	45.482	25.290	40.961

Notes. The table shows regression results using various specifications exploring the nonlinearity of estimated class-size effects. Columns (1) and (2) are inspired by Connolly and Haeck (2022), who estimate class-size effects around the lower threshold, where average class size expectedly drops 13.5 students (corresponding to 48%) between cohort enrolment sizes 28 and 29, separately from other thresholds, where the relative expected reduction is smaller (32% around the second and 28% around the third). We cannot reject that the estimated coefficients of the marginal effect of a one-student class size reduction in columns (1) and (2) are equal across thresholds. Column (3) includes a second-order polynomial in class size, using a second-order polynomial in predicted class size as excluded instrument. Columns (4)-(6) are inspired by Hojo (2013) and requires one to set the break point class size, t, where class-size effects deviate. Kedagni et al. (2021) estimate that the optimal class size for attainment is 19, thus, in column (4) we set $t = 19$. In column (5), t equals 21, and in column (6) t is set to the school average class size in the introductory grades K-2. Columns (4)-(6) uses *PredCS* and $1[PredCS \geq t] \cdot (PredCS - t)$ as excluded instruments. Cluster-robust standard errors in parentheses, * $p < 0.1$.