Impacts of School-Wide Positive Behavior Support (SWPBS). Results from National Longitudinal Register Data

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Short title: Impacts of SWPBS

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Author note

The authors declare that there is no conflict of interest. The standards of the Norwegian Social Science Data Services were followed throughout the conduct of the study. The study was financed by a grant from the Research Council of Norway (grant #238050). The Ragnar Frisch Centre for Economic Research was project manager. All authors have contributed to writing the article. Raaum, Kirkebøen, and Borgen have analyzed and interpreted the data. Ogden and Sørli have provided school-level data on the SWPBS intervention. The register data was made available by Statistics Norway.

Abstract

Problem behavior in schools may have detrimental effects both on students' well-being and academic achievement. A large literature has consistently found that School-Wide Positive Behavior Support (SWPBS) successfully address social and behavioral problems. In this paper, we used population-wide longitudinal register data for all Norwegian primary schools and a difference-in-difference (DiD) design to evaluate effects of SWPBS on a number of primary and secondary outcomes, including indicators of externalizing behavior, school well-being, pull-out instruction, and academic achievement. Indications of significantly reduced classroom noise were found. No other effects were detected. Analyses revealed important differences in outcomes between the intervention and control schools, independent of the implementation of SWPBS, and that a credible design like DiD is essential to handle such school differences.

Keywords: SWPBS, difference-in-difference design (DID), longitudinal, intervention, register data

Problem behavior in schools may have detrimental effects on both students' well-being and academic achievement. Research shows that students who display disruptive and aggressive behaviors are at risk of academic problems and marginalization (Bradshaw, Waasdorp, & Leaf, 2015), and these students can have negative spillover effects for the rest of the classroom (Carrell & Hoekstra, 2010). To meet such challenges, schools have increasingly turned to program interventions (Benner, Nelson, Sanders, & Ralston, 2012), such as School-Wide Positive Behavior Supports (SWPBS or SWPBIS).

SWPBS is an evidence-based, data-driven, systematic school-wide program implemented by more than 23,000 schools in the United States (U.S.) and internationally (Gage, Whitford, & Katsiyannis, 2018). The primary aim of SWPBS is to address social and behavioral concerns in schools by reducing disruption and more severe problem behavior, such as violence and bullying. By improving the learning environment, SWPBS is also assumed to impact academic achievements, although improving academic outcomes has not been a main focus in the intervention (Gage, Sugai, Lewis, & Brzozowy, 2015).

A large literature mainly from the U.S., has consistently found that SWPBS successfully address social and behavioral problems, with the most convincing evidence coming from randomized controlled trials (RCT) (e.g., Bradshaw, Waasdorp, & Leaf, 2012). However, while RCTs provide credible effect estimates for the participants included in the trial, the results are not always generalizable to the target population or related target populations. Participants who volunteer to participate in RCTs may differ from the target population in important aspects (Stuart, Bradshaw, & Leaf, 2015), such as being more likely to implement interventions in accordance with the model (Pas & Bradshaw, 2012).

Unlike in randomized trials or pilot studies, implementation of evidence-based interventions in regular practice (i.e., scale-up) is often poor (Pas & Bradshaw, 2012). This is problematic because intervention effects are in general best when interventions are

implemented in accordance with the original model tested in research, without violations of goals, underlying theory, and guidelines (i.e., fidelity) (Domitrovich et al., 2008). Results in RCTs are accordingly likely to be stronger than in real-world conditions (Bradshaw et al., 2015; Flay et al., 2005). Recently, there have been efforts to examine whether program participants in RCTs differ from the wider population (Stuart & Rhodes, 2017). However, so far no study has used population-wide register data to evaluate SWPBS.

In this paper, population-wide longitudinal Norwegian register data were used to evaluate the effects of SWPBS (called N-PALS in Norway) on a number of primary and secondary outcome variables, including indicators of externalizing behavior, school well-being, pull-out instruction, and academic achievement. An advantage of register data is that they include information on all schools that have ever implemented SWPBS in Norway, not only those who volunteer in research, and also all other schools. Additionally, the register data allows for comparison of SWPBS schools and control schools three years prior to and five years after the initiation of the intervention, which is a considerably longer evaluation period than in most studies (Madigan, Cross, Smolkowski, & Strycker, 2016).

Longitudinal data on SWPBS schools and control schools allow for use of a difference-in-difference (DiD) design, which has not been previously used to evaluate SWPBS (Mitchell, Hatton, & Lewis, 2018). DiD has become a key method in the evaluation literature, as it enables handling of both unobserved (stable) heterogeneity between schools and (general) changes over time unrelated to the intervention (Smith & Todd, 2005). In the current study, impacts of SWPBS were investigated by comparing different cohorts of students within the same schools, before and after the implementation of SWPBS, and after accounting for changes in student composition and cohort effects.

Previous research on SWPBS

Studies from the U.S. have shown that SWPBS reduces problem behavior, office discipline referrals, suspensions, and non-attendance (for a review, see Horner, Sugai, & Anderson, 2010). However, less than a third of the studies are grounded in rigorous designs, with most studies being case studies and cross-sectional studies (Chitiyo, May, & Chitiyo, 2012).

Of particular interest are three RCTs, all of which consistently indicate that SWPBS improves behavior. Benner et al. (2012) found that SWPBS reduced externalizing problem behaviors (e.g., aggression, noise), and Horner et al. (2009) found that SWPBS resulted in an improvement in students' perceived school safety. Bradshaw et al. (2012) found that SWPBS had a positive effect on children's behavior problems, concentration problems, social-emotional functioning, and prosocial behavior. Using the same data as Bradshaw et al. (2012), Bradshaw, Mitchell, and Leaf (2010) found significant reduction in student suspensions and office discipline referrals and Waasdorp, Bradshaw, and Leaf (2012) found that SWPBS lowered the rates of teacher-reported bullying and peer rejection.

The SWPBS model mainly addresses social and behavioral problems in school (Horner et al., 2010). However, when problem behavior interferes with teaching, reduced disruption may increase students exposure to classroom instruction and consequently to increased academic engagement and learning (Gage et al., 2015). More than 20 studies have examined the effects of SWPBS on academic achievements. The majority of studies report that SWPBS seems to improve academic outcomes in the U.S., but these studies have used a descriptive design or a case study design which does not account for selection effects (for a review, see Gage et al., 2015).

Experimental studies have not found any effect of SWPBS on academic achievement (Benner et al., 2012; Bradshaw et al., 2010; Horner et al., 2009), while quasi-experiments

have reported mixed effects (Caldarella, Shatzer, Gray, Young, & Young, 2011; Freeman et al., 2016; Gage, Leite, Childs, & Kincaid, 2017; Gage et al., 2015; Lane, Wehby, Robertson, & Rogers, 2007; Madigan et al., 2016). However, small sample sizes and a short research period (Madigan et al., 2016) limit the validity of the outcomes. Accordingly, there is still an open question whether the model impacts academic achievement.

Although most of the evidence on SWPBS comes from U.S. studies, two sampling studies with a quasi-experimental design have evaluated SWPBS in Norway (Sørli & Ogden, 2007, 2015). Behavioral problems in schools are major challenges in Norway, with some surveys indicating more problem behavior, such as classroom disruption, in Norway than in other western countries, highlighting the need for school interventions (Sørli & Ogden, 2015). Results after three years of implementation in the first 28 SWPBS schools in Norway, indicated positive main effects in the small to large range on both severe and less severe problem behaviors, pull-out instruction, and classroom climate (Sørli & Ogden, 2015), and on teachers' practice and perceived efficacy (Sørli, Ogden, & Olseth, 2016).

The present study

The present study contributes to the literature by using register data and a difference-in-difference (DiD) design to evaluate the effects of SWPBS on a number of primary and secondary outcome indicators. It complements prior Norwegian studies by evaluating effects for all schools that have implemented SWPBS. Moreover, no studies have explored potential effects of SWPBS on academic achievement and bullying in Norway. Although these are secondary outcomes, it is of interest to search for possible ripple effects on bullying and achievement. There has been growing concerns regarding bullying, and positive school-wide prevention efforts such as SWPBS has been suggested as an effective intervention to reduce

bullying (Waasdorp et al., 2012). Academic outcomes are, together with behavior and attendance, important indicators of school effectiveness (Freeman et al., 2016).

Based on SWPBSs intentional purpose and prior research, the following research question were formulated for this study:

- Does SWPBS have long-term effects on the prevalence of classroom noise and bullying?
- Does SWPBS have long-term effects on students' academic achievements and well-being in school?
- Does SWPBS result in reduced use of pull-out instruction for special need students?

Method

Participants

Compulsory education in Norway starts at the age of six and lasts for ten years, with primary education in grade 1-7 and lower secondary education in grade 8-10. Schools are publicly funded and very few are private. Compared to other European countries, Norway has an inclusive school setting and few special schools (Sørli & Ogden, 2015). Students attend school in their local catchment area and there is no formal tracking by student ability. All Norwegian primary schools (grades 1-7) were included in the study (N=2,365). Each school and student has a unique identifier that allows matching of SWPBS schools to population-wide register data. The study combined school-level data on program implementation (fidelity), obtained from The Norwegian Center for Child Behavioral Development (NCCBD), with school-level and student-level register data.

The *unit of analyses* was “school grade cohort”, which closely corresponds to birth cohorts, as there is no grade retention in Norway. Outcomes were observed for each school

grade cohort over a nine-year period (three years before to five years after SWPBS was initiated) and linked to when the intervention model was implemented. The student-level variables included students born or immigrated to Norway before the age of six, and who completed lower secondary school the calendar year they turned 15, 16, or 17 years.

Approximately 95 percent finish compulsory school by the age of 16. The matching of students to schools is based on residential address. As explained in detail in Appendix 1 (appendices available online in the Supporting Information section), uncertainty in this matching may result in a slight bias in the effects on standardized national tests, while effects on classroom noise, bullying, well-being, and special needs education are unaffected.

Sensitivity analysis in Appendix 1 suggest that effect size is similar using predicted and actual school (Figure A1.1).

The Intervention

SWPBS is a structured yet flexible whole-school approach with the main goal to prevent and reduce school problem behavior, and to promote an inclusive learning environment that can facilitate safety and the psycho-social functioning and learning of all students (Sørli & Ogden, 2015). The focus is on positive, systematic, data-driven, educative, and reinforcement-based practices conducted within a framework of research-based, collective (school-wide), proactive, and predictable approaches. The core features of SWPBS builds on decades of research in education, mental health, and behavior analysis, which in the SWPBS model is organized as a school-wide approach with multiple tiers of support and interventions, and systems to improve fidelity and sustainability (Horner et al., 2014). The prevention model involves all staff and students, and takes approximately three to five years to fully implement.

The SWPBS is organized according to the principle of matching interventions to students' risk level (Sørli & Ogden, 2015). More specifically, the intervention model relies on a three-tiered system of evidence-based preventions and supports. Tier I interventions (universal, primary prevention) apply to everyone and all settings in the school with the goal to "prevent problems by defining and teaching consistent behavioral expectations across the school setting and recognizing students for expected and appropriate behaviors" (Lohrmann, Forman, Martin, & Palmieri, 2008, p. 256). Tier II interventions (selected, secondary prevention) are designed for students at moderate risk for severe behavior problems and who might not respond sufficiently to the universal interventions. The interventions are standardized and mostly delivered in short-term organized small-groups. Tier III (indicated, tertiary prevention) targets the few students with or at high risk of conduct disorder. The interventions at this level are intensive, highly individualized, and multi-modal.

Since 2002, SWPBS has been implemented in 244 primary schools in Norway (9%). The core model components and implementation structure of the Norwegian SWPBS model (called N-PALS) are equal to the U.S. version. The core components are: 1) school-wide positive behavior support strategies including teaching of school rules, positive expectations, systematic encouragement of positive behavior, 2) monitoring of student behavior using the School-Wide-Information system (SWIS), 3) school-wide corrections with mild and immediate consequences, 4) time-limited small group instruction for students at risk, 5) individual interventions and support plans for high-risk students, 6) classroom management skills for teachers, and 7) parent information and collaboration strategies. Except for minor adaptations of the training materials (e.g., pictures, videos, response cards, concepts), no changes were made when SWPBS was transferred to Norway. N-PALS does not include any evidence-based interventions to promote academic performance, similar to the original model.

The school's readiness for implementation was initially assessed, and approval from at least 80% of the staff was required. Each school appointed a representative team (5 persons) who were trained on a monthly basis to plan, inform, carry out, monitor, and report on the intervention outcomes at their school. The teams were locally trained and supervised by a coach for two years (10 sessions/2 hours per year). The coaches were trained (1 year) and certified by the national implementation team at NCCBD. All training was nationally standardized and free of charge (except travel costs). The school team trained the rest of the staff in key features and intervention components and attended four half-day regional booster session per year. The schools used various web-based feedback systems based on nationally standardized assessment tools to secure data-based decisions and fidelity.

In this study, students are considered exposed to the intervention if they attend grade 4-7 in a school that implements SWPBS. The share of exposed students has increased from close to zero for the 1994 cohort to about 11 percent of those born in 2000 and later (Figure 1). Across the sample of nine cohorts, about eight percent were ever exposed to the program.

Figure 1. Percentage of students exposed to SWPBS during grade 5 to 7 across birth cohorts

Measures

Primary outcomes. Prior studies have used reliable multi-item assessment scales to capture changes in more and less severe externalizing behaviors within and outside the classroom context (Sørli & Ogden, 2015). Because such measures are not available in registers, single items from annual nation-wide surveys among all 7th graders in Norway (>90% response rate) were selected as proxy variables.¹ While Sørli and Ogden (2015) used teacher assessments, this study used student-reported frequency of *classroom noise* and *bullying* in the second semester of 7th grade (age 13), obtained from the Pupil Survey administrated by the Norwegian Directorate for Education and Training. The item classroom noise was measured on a five-point scale (*1 = fully agree with classroom order, 5 = fully disagree with classroom order*), and was for the analyses standardized to mean = 0, standard deviation = 1. Bullying was measured by asking students how often they had been bullied by peers at school during the last months. Bullied was defined as the share of students being bullied at least 2-3 times a month.

Secondary outcomes. Student-reported well-being in school from the Pupil Survey was measured in 7th grade with one item (*5=enjoy school very much, 1=does not enjoy school at all*) and standardized to mean=0, standard deviation=1. Academic performance refers to the schools' average score on standardized national tests in literacy, English (foreign language), and numeracy. Standardized national testes in literacy, English, and numeracy were standardized for each student (mean=0, standard deviation 1), averaged for each student, and then school averages were computed. All tests were performed early in 8th grade (age 13), the first semester after leaving a SWPBS school. Data on special needs education were obtained from the nation-wide compulsory education information system (GSI), administrated

¹ The following questions was used (our translations): (1) Classroom noise: "The classroom order is good." (2) Bullying: "Have you been bullied by other students at school the last months?" (3) Well-being: "Do you enjoy school?"

by The Norwegian Directorate for Education and Training. These data were reported by school staff and are measured in this study at the overall school level. The share of special education students and the share receiving most of their instruction outside ordinary class (i.e., pull-out instruction) were included as secondary outcome indicators.

Treatment (intervention). The treatment indicator tracks the position of each school grade cohort relative to the year of program implementation. Students finishing primary school (grade 7) just before SWPBS was implemented were labelled -1. The next cohort, exposed to SWPBS for one year (grade 7), was labelled 1. Cohort 4 was the first cohort exposed through grades 4-7. For each school grade cohort outcomes in grade 7 or 8 were analyzed.

Control variables. The following variables from register data were included as covariates; student composition within schools using gender, mother's and father's level of education (9 dummies for each parent, from no education to PhD), mother's and father's earnings and earnings squared (in 1,000 Norwegian Krone), immigrant background (6 dummies), and interactions between school county (dummies) and school cohort (dummies). Descriptive statistics are presented in panel B of Table 1.

Fidelity. The Effective Behavior Support Self-assessment Survey (EBS, 46 items) was routinely completed each year (from 2008 onwards) by teachers and staff in all intervention schools and used as measure of perceived program fidelity, and explained in more detail in appendix 4.

Table 1 Descriptive statistics. Outcomes and student composition.

	N	Mean	SD _{Total}	SD _{Between}	SD _{Within}
Panel A: Student outcomes					
Classroom noise	11,591	2.61	0.477	0.269	0.404
Bullied (=1)	17,374	0.074	0.068	0.033	0.061
Academic performance	19,245	-0.002	0.305	0.227	0.205
Well-being	17,375	4.26	0.276	0.156	0.234
Pull-out instruction (=1)	21,080	0.053	0.040	0.028	0.029
Special education (=1)	21,079	0.070	0.038	0.031	0.023
Panel B: Student composition					
Girls (=1)	11,591	0.489	0.107	0.054	0.096
Fathers' education	11,590	4.46	0.623	0.545	0.303
Mothers' education	11,591	4.66	0.593	0.500	0.327
Fathers' earnings	11,590	441	100	89	44.6
Mothers' earnings	11,591	228	60.3	50.1	33.6
Native Norwegians (=1)	11,591	0.919	0.129	0.119	0.043
First-generation immigrants (=1)	11,591	0.024	0.038	0.023	0.030
Second-generation immigrants (=1)	11,591	0.056	0.112	0.106	0.031

Note: All results with student weights. The standard deviations in the SD_{Between} and SD_{Within} columns show the degree to which the outcome variables vary between and within schools, respectively. Dummy variables are indicated with (=1), and the mean of the dummy variables equal the proportion of cases with a value of 1.

Analytic approach

Schools implementing interventions like SWPBS may differ from other schools (e.g., higher levels of problem behavior, more proactive school management). To account for selection of schools into treatment and time effects common to all schools, a difference-in-differences (DiD) design was preferred. This design compares changes in outcomes within schools following implementation of SWPBS with corresponding changes in other schools. A linear regression model controlling for unobserved persistent differences between schools, general time trends, and time-varying differences in student composition was estimated (see Appendix 2 for details). An advantage of DiD is that it accounts for all time-invariant differences between schools, such as stable school traits, teacher characteristics, and student characteristics, irrespective of proxies for these differences.

The key identifying assumption is that the outcomes would have evolved similarly over time in both intervention and control schools absent of implementing SWPBS (net of

time-varying covariates). This “parallel trends”-assumption is untestable, but its credibility can be tested indirectly by comparing trends for SWPBS and non-SWPBS schools prior to implementation. Before implementation, there may be between-school differences, but these should be stable.

The DiD model was estimated with the year prior to implementation as reference category. After estimating the regression model, a linear combination of coefficients was used to rescale the coefficients to the difference from an average of one, two, and three years before implementation. A summary measure of the effects of SWPBS is provided by comparing the post period (2-5 years after program initiation, reflecting the minimum time considered necessary to fully implement SWPBS) with the difference from the pre-period (1-3 years before implementation). Averaging effects over several years increases the statistical power when studying persistent effects.

Results

Data description

Table 1 shows descriptive statistics for outcomes (panel A) and control variables (panel B). School-by-grade cells are weighted with number of students. The outcomes (except test scores) are shown in original units without standardization. Substantially fewer number of observations for classroom noise reflect that registration of this question started later than bullying and well-being, meaning that the number of available cohorts are fewer. On average, 7.4 percent of the students were bullied, 7.0 percent received special education, and 5.3 percent received most instruction outside regular class (i.e., the mean of the dummy variables). While student composition, test scores, and share of special education students mostly varied between schools, the remaining outcomes varied as much or more over time within schools.

Compared to other Norwegian schools, the intervention schools tended to have less classroom noise, more bullying, higher test scores, and more pull-out instruction *prior* to SWPBS (Table 2). Significant difference in bullying remained after controlling for student composition, highlighting the need for a research design able to correct for stable differences in outcomes not related to observable proxies.

Table 2 Average fixed effects difference between SWPBS schools and control schools during pre-intervention years.

	(1)	(2)
Classroom noise	-0.048***	-0.023
Bullied	0.0094***	0.0027**
Academic performance	0.016*	0.0074
Well-being	-0.004	0.002
Pull-out instruction	0.0050***	0.0014
Special education	-0.0006	-0.0012
Student composition controls	No	Yes

Note: Results in column (1) are without any control variables while the results in column (2) includes the following student composition variables: Share female, fathers' and mothers' education and earnings, immigrant background, birth cohort, school county X birth cohort.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Validity of research design

To check the validity of the identification strategy, we analyzed whether there was evidence of differential changes in SWPBS and control schools before initiation of SWPBS. If such “placebo effects” were significant, this would indicate confounding variation and the research design could not be trusted. Figure 2 presents the estimated “placebo effects” (pre-implementation cohorts) and estimated program effects. The placebo effect estimates were small and mostly insignificant, indicating little evidence of differential changes and systematic trends in the intervention schools (relative to control schools) before implementation. We concluded that the research design seemed valid, and that the effect estimates are informative.

Figure 2 Effect estimates (after) and pre-program heterogeneity (DiD) with 95% CI.

Note: Outcome metrics: Standardized for classroom noise, academic performance, and well-being.

Observed share for bullied, pull-out instruction, and special education. The dotted line separates coefficients before (-3 to -1) and after (1 to 5) initiation of SWPBS.

Main program effects

The presumably valid estimates of program effects are presented in Figure 2 by number of years after initiation of SWPBS, which correspond to years exposed (coefficients in Table A3.1, Appendix 3). For the primary outcomes, there were indications of reduced

classroom noise. The estimate after two years was significant at the 5% level, but the estimates for subsequent cohorts, while systematically negative, were not significant. No intervention effect was observed on bullying or on any of the secondary outcome indicators.

In order to increase precision and power, we merged outcome periods and estimated average effects for years 1-5 and 2-5 after initiation of SWPBS. Results are presented in Table 3. Given that SWPBS is expected to take several years to implement, the estimates for years 2-5 are the most relevant. For classroom noise we found an average reduction of 5.7 percent of a standard deviation for years 1-5 and of 7.5 percent for years 2-5. The former is not significant, while the latter is significant at the 10 percent level with the 95 percent confidence interval (CI) ranging from -16.3 to +1.4. For bullying we found a non-significant increase of respectively 0.6 and 0.7 percentage points (CI for years 2-5 ranged from -0.2 to +1.5). Estimated average effects for test scores, well-being, special education, and pull-out instruction were all insignificant.

Table 3 Effect estimates

	(1) Classroom noise	(2) Bullied	(3) Academic performance	(4) Well- being	(5) Pull-out instruction	(6) Special education
1-5 years	-0.057 (0.042)	0.0058 (0.0042)	-0.012 (0.012)	-0.026 (0.023)	0.0024 (0.0023)	0.0027 (0.0018)
2-5 years	-0.075* (0.044)	0.0067 (0.0044)	-0.014 (0.013)	-0.025 (0.023)	0.0025 (0.0024)	0.0026 (0.0019)
N	11,464	17,242	19,079	17,242	20,882	20,881

Note: Cluster robust standard errors in parentheses. Outcome metrics: Standardized for classroom noise, academic performance, and well-being. Actual share for bullied, pull-out instruction, and special education. Student composition controls: Share female, fathers' and mothers' education and earnings, immigrant background, birth cohort, school county X birth cohort

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure 3 Comparing schools implementing with high fidelity ($\geq 80\%$) and those that do not ($< 80\%$).

Note: Outcome metrics: Standardized for classroom noise, academic performance, and well-being. Observed share for bullied, pull-out instruction, and special education. The dotted line separates coefficients before (-3 to -1) and after (1 to 5) initiation of SWPBS. Results shown with 95% CI.

Effects in schools with high fidelity

From prior research it was expected that high fidelity was required to produce an effect of SWPBS (e.g., Bradshaw et al., 2010; Sørli & Ogden, 2015). Results from the Effective Behavior Support Self-assessment Survey (EBS) indicated that only 30 percent of the Norwegian schools had implemented SWPBS with sufficient fidelity (80%) within three years after initiation of SWPBS. However, Figure 3 shows that there was no evidence of differential effects when effect estimates in schools with high and low fidelity scores were compared (for detailed results on fidelity and details on Figure 3, see Appendix 4).

Discussion

In this article, a credible non-experimental research design and population-level longitudinal registry data were used to study school-level effects of SWPBS in Norwegian primary schools. Indications of significantly reduced classroom noise (primary outcome) were found. This is in line with several previous studies, including RCTs and credible non-experimental designs, where reduced student problem behavior follows from implementation of the SWPBS model (e.g., Benner et al., 2012; Bradshaw et al., 2012). While several previous studies are based on teacher-assessed outcomes, the present study is notable in finding indications of effects on classroom noise reported by students.

The present study is unable to detect effects on a range of other outcomes. Contrary to results from a previous study (Waasdorp et al., 2012), no effects were found on bullying (primary outcome). Likewise, the effects on students' well-being and academic performance as well as pull-out instruction (secondary outcomes) were all close to zero and insignificant. The lack of effect on test scores in the current study is in line with results from previous high-quality studies (e.g., Bradshaw et al., 2010; Horner et al., 2009), and no academic support is included in SWPBS in Norway.

The present study is an example of a study where changes in at-scale outcomes do not match what one would expect from smaller-scales studies (Eisner & Malti, 2015). In general, it is hard to evaluate what other developments contribute to aggregate changes in outcomes. The DiD design explicitly accounts for sources of change across cohorts shared by program and control schools. Our effect estimates reflect observed outcomes compared to the outcomes one would have expected in the absence of SWPBS, including that the schools may initiate other interventions or act differently in other ways. The lack of substantial effects may partly be due to that many control schools implement other programs (Bradshaw et al., 2010). In the current study, data on other programs were not available. Thus, we do not know whether SWPBS replaces other, equally effective programs.

Another possible explanation of the limited effects in the present study is that few schools implement with fidelity. Low fidelity is a widespread problem in SWPBS schools, with only two out of 10 effectiveness studies reporting high fidelity among schools (Chitiyo et al., 2012). However, in a previous study including 28 of the first SWPBS schools in Norway, 75% implemented with high fidelity after three years (Sørli & Ogden, 2015). High fidelity is also reported in RCTs from the United States (Pas & Bradshaw, 2012). The present study estimates average intervention effects of SWPBS in all Norwegian schools which have implemented SWPBS (N=244). Only 30% of the schools implemented with fidelity after three years, suggesting that fidelity is a major challenge in scale-up of SWPBS.

When fidelity is low in many schools, the estimated average effect will reflect this. We examined whether the effects were stronger for high-fidelity schools without finding evidence of differential effects, but the small number of such schools made these estimates less precise. However, reliable assessment of fidelity and investigating differential effects by fidelity is more problematic than acknowledged in the literature. For example, schools with high perceived fidelity or that voluntarily continue to answer surveys may be schools with better

outcomes and/or greater initial motivation for change. Restricting analyses based on fidelity scores or survey response may confound fidelity and other characteristics of schools, and thus give biased estimates.

Other possible explanations for the partly conflicting results with previous studies relate to data and methods. While most studies have used teacher assessed outcome variables, particularly office discipline referrals (Chitiyo et al., 2012), the outcomes in the present study were student-assessed survey data, test scores, and register data. For example, Sørli and Ogden (2015) found intervention effects based on teacher assessments but not on student-assessed outcomes. On methods, we study long-run effects and take pre-existing hard to observe differences in to account. Pre-existing school-differences were found to affect the effect estimates unless they were adequately accounted for, suggesting that different empirical strategies across studies may partly explain the contrast between effects reported by the current and prior studies.

Strengths and limitations

Few studies have evaluated SWPBS using rigorous designs (Chitiyo et al., 2012). The major strength of the present study is national coverage and longitudinal data with very limited attrition. The register data were collected yearly by school authorities in a consistent way for all schools and students in grades 7 and 8, independently of SWPBS. The response rates for the survey-based student-reported outcomes are very high compared to other surveys. The test score data have similar high participation rates. We also study whether there is differential attrition in SWPBS and controls schools, finding no evidence of this, and no indication of biased effect estimates due to differential attrition (see Appendix 6).

The data include school outcomes (as reported by students) several years after the initiation of SWPBS, and allow for investigation of more long-lasting effects of SWPBS than

in previous studies (Madigan et al., 2016). The key benefit of the DiD design used in this paper is the avoidance of bias from factors changing over time unrelated to SWPBS as well as unobserved persistent differences between schools. A less comprehensive design would have given misleading estimates (see Appendix 5). For example, after implementing SWPBS, the intervention schools had more classroom noise and higher levels of bullying than other schools. However, this was the case also before implementing SWPBS, and thus not an effect of the program.

Although we conclude that the data are informative, and the design is valid, there are several important limitations. The present study focuses on average (school-level) effects and the design possesses sufficient power to rule out relatively small average effects. For example, for average effects on bullying over years 2-5, significant effects were detectable if they exceeded 0.2 percent of a standard deviation. However, there may be larger effects for subgroups of students (e.g., students at elevated risk). Even if the student response rates are high, at-risk students may be overrepresented among those not answering. Similarly, at-risk students may be overrepresented among the relatively few students that do not take the standardized tests. Thus, while the estimates are informative about average effects, they do not include evidence on effects for particularly targeted students.

In terms of reliability and validity, there are both benefits and limitations from studying variables collected for other purposes than program evaluation. Moreover, there are pro and cons of student-reported outcomes compared to teacher-reported data. To ensure comparability between survey years, outcomes are based on single items and this may reduce reliability. Regarding validity, the variables studied may not be sensitive to potential changes caused by SWPBS. The same variables are used by Norwegian educational authorities to monitor bullying, well-being, and academic performance. The bullying variable is based on the Olweus Bullying Questionnaire and has been shown to have high reliability and validity

(Olweus, 2013). Research also show that test scores predict students' later outcomes.

However, analysis of the validity of classroom noise and well-being are scarce. Additionally, while effects on variables collected for other purposes would suggest generalizable effects beyond the SWPBS constructs, there remains a question to what extent the outcome variables match the program objectives.

It may also be hard to get consistent measures of effects based on subjectively assessed outcomes, using reports from either students or teachers. In general, analyses of the Norwegian student and teacher surveys mostly show high internal reliability across items within survey and topic, and moderate positive correlations between student and teacher responses on similar items across surveys. There are further complications studying effects of SWPBS related to expectations and perceptions. For example, even if disruptive behavior is objectively reduced, students and teachers may adjust their expectations and the effect estimates will be bias towards zero. Additionally, both teachers' and students' perception of disruptive behavior may change as an effect of the program, which can give a positive or negative bias (Gage et al., 2018).

Conclusion

In this paper, population-wide register data and a differences-in-differences (DiD) design were used to evaluate school-level effects in a scale-up of SWPBS in Norway on classroom noise, bullying, well-being, academic achievement, and special needs education. While some evidence of reduced classroom noise was found, there were no significant effects on other outcomes. No effect on academic achievement is in line with previous high-quality studies, while for other outcomes less favorable effects were found than in previous studies, including RCTs from the US. Intervention effects are likely stronger in effectiveness trials where the program is evaluated under more optimal conditions of delivery (i.e., higher

fidelity), which is one likely explanation for the less favorable outcomes in the present study. Another explanation is that outcome variables selected from register data are less suited for measuring primary outcome effects of SWPBS. The DiD design is generally considered to be a credible identification strategy when randomization is not feasible. The register data allow for studying all schools, irrespective of implementation quality or motivation for answering program-provided surveys, providing precise and arguably unbiased estimates. Schools were followed for several years before and after initiation of SWPBS. This enabled both analyses of longer-term effects than previous studies, investigation of differences between schools prior to implementation, and evaluation of the credibility of the DiD design.

We found that DiD was valid in this particular case, and that less comprehensive designs would provide misleading results. Changes in outcomes across student cohorts, unrelated to SWPBS, imply that a before-after comparison within SWPBS would give biased estimates of program effects. Likewise, comparing intervention schools with other (control) schools disregarding pre-existing differences would also have provided biased effect estimates. The current study exemplifies the relevance of the DiD design as well as the usefulness and limitations of using register data in future evaluations of school interventions.

Supporting information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Appendix 1. School and student identification.

Appendix 2. The difference-in-differences (DiD) model.

Appendix 3. Coefficients from Figure 2.

Appendix 4. Fidelity.

Appendix 5. School heterogeneity illustrated by fixed effects distributions.

Appendix 6. Response rate.

Appendix 7. Raw differences between SWPBS schools and control schools.

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Appendix 1. School and student identification

There is no central register of compulsory school students in Norway, thus we generally do not know which school students attend and need to predict school. Predicting students' school potentially introduces some bias in our effect estimates; however, the consequences is mostly minor. Except for academic performance, all other outcome variables are measured at the school level, including classroom noise, bullying, well-being, pull-out instruction, and special needs education. For these outcomes, we depend on the school prediction only with regard to the control variables (e.g., socioeconomic composition), which, given our DiD design (see Appendix 2), is a minor concern. The outcome variable academic performance on the other hand is measured at the student level, and any mismatch between actual and predicted school may have larger consequences.

To assign students to schools, we used the fact that Norwegian primary school students overwhelmingly attend their local schools (less than 5 per cent attend private schools) and imputed school assignment based on residential address. Register data identifies the residential location of students, in particular the basic statistical units (basic districts). There are about 14,000 such units, which according to Statistics Norway constitute "... small, stable geographical units which may form a flexible basis to work with and present regional statistics. (...) geographically coherent areas. (...) homogeneous, with respect to nature and basis for economic activities, conditions for communications, and structure of buildings." The units have 0-6000 inhabitants (mean = 379).

From 2007 and onwards students take standardized tests in grades 5 and 8 (later also in grade 9). Results are recorded at the student level, and include school id and student id. Based on the standardized test data for 5th graders in 2007-2009, we found the most frequently attended school for students in each basic statistical unit. We then imputed school characteristics, including SWPBS participation, using these modal schools.

For students with standardized test data, we could compare actual and predicted school id. We found that about 85 per cent of students in the cohorts used to construct residence school links attended the predicted school. For other cohorts we have slightly worse identification of schools. Still, for each cohort within +/- four years of the cohorts used to impute schools we found that more than 80 per cent attended the predicted school. These shares were similar for SWPBS and control schools.

Over longer time spans we cannot use test score data to directly evaluate the relevance of the predicted school attended. However, the vast majority of schools have existed since the

start of the school register in 1992. Also, predicting the number of students by gender*grade*year*school and correlating this predicted student counts with observed counts, we found a correlation of 0.89. Thus, we conclude that, even over long time spans, we were mostly able to correctly predict school assignment based on residence.

In the evaluation of SWPBS we were mainly concerned about school attend around the time of introduction of the program, which matches closely with the years used to impute schools. However, in some cases we assigned students to the wrong school, and thus, some students were wrongly recorded as exposed or non-exposed case, which caused a slight attenuation bias in the estimates.

Since we observe actual school for all 5th graders in 2007 and later, we can check whether effect estimates based on actual school in 5th grade differs from effect estimates based on predicted school. This requires us to exclude school-cohorts that are 5th graders in 2004-2006, which is a third of the main analysis sample. The effect estimates and confidence intervals cannot be compared directly to the results in Figure 2 in the main text. Figure A1.1 demonstrates that the effect estimates are unaffected by using predicted school in this subsample.

Figure A1.1 Comparing DiD effect estimates based on school predicted based on residence and actual school from standardized tests in 5th grade with 95% CI.

Note: Subsample of the entire analysis sample, excluding 5th graders in 2004-2006. The effect estimates for predicted and actual school is based on the same sample. The dotted line separates coefficients before (-3 to -1) and after (1 to 5) initiation of SWPBS.

Appendix 2. The difference-in-differences (DiD) model

The basic model is:

$$(1) \quad Y_{cs} = \beta_0 + \beta T_{cs} + \delta \bar{X}_{cs} + \gamma_c + \mu_s + \varepsilon_{cs}$$

, where Y_{cs} is the outcome (e.g., bullying) of cohort c in school s , β_0 is the constant term, T indicates whether a given cohort in a given school were enrolled after the implementation of SWPBS ($T = 1$), γ_c is the birth cohort fixed effect, μ_s is school fixed effect, and $\bar{X}_{cs}$ is observed time-varying school-level student composition (share of students that are female, fathers' and mothers' average education and earnings, immigrant background, school county X birth cohort). Cohort refers to the year students exit primary school (and exposure to SWPBS ends). ε is a residual, capturing unexplained variation in results at the school-by-cohort-level. Throughout, we clustered residuals at the school level to allow unexplained difference to be correlated over time within school. To account for differences in school size, we estimated a weighted regression where the weights equal the average student size in 7th in the period before SWPBS was implemented (i.e., prior to 2002).

The key identifying assumption was that the evolution of the outcome over time should be parallel for both SWPBS schools and control schools in the *absence* of the SWPBS intervention (net of time-varying covariates). This “parallel trends”-assumption is untestable, but we could evaluate its credibility indirectly by comparing trends for program and non-program schools prior to implementation. Thus, in the preferred model specification we estimated the effects of SWPBS with leads and lags of program implementation

$$(2) \quad Y_{cs} = \beta_0 + \sum_{p=-3}^5 \beta_p T_{csp} + \delta \bar{X}_{cs} + \gamma_c + \mu_s + \varepsilon_{cs}$$

, where β_p parameters identify any pre-program differentials ($p < 0$) and post-implementation effects ($p > 0$) as $T_{csp} = 1$ when the outcome of cohort is measured *with a time distance of p years* since the implementation of the program. For example; β_3 measures the effect on Y for students exiting primary school three years after implementation of SWPBS, i.e., of being exposed SWPBS for three years. If the assumption of the parallel trends holds, then $\beta_p = 0 \forall p < 0$, i.e., there should be no differences between cohorts within the same school before the implementation (net of general time trends).

Appendix 3. Coefficients from Figure 2**Table A3.1** Effect estimates (cf., Figure 2).

	(1) Classroom noise	(2) Bullied	(3) Academic performance	(4) Well- being	(5) Pull-out instruction	(6) Share special education pupils
SWPBS						
before/after:						
-3	0.0012 (0.0480)	0.0077 (0.0050)	-0.0139 (0.0143)	-0.0132 (0.0216)	-0.0037* (0.0018)	-0.0006 (0.0010)
-2	0.0495 (0.0417)	-0.0025 (0.0053)	-0.0093 (0.0133)	0.0038 (0.0223)	0.0021 (0.0013)	-0.0014* (0.0007)
-1	-0.0507 (0.0450)	-0.0052 (0.0042)	0.0232+ (0.0134)	0.0094 (0.0187)	0.0016 (0.0018)	0.0020+ (0.0011)
1	0.0162 (0.0545)	0.0023 (0.0082)	-0.0037 (0.0162)	-0.0315 (0.0327)	0.0020 (0.0022)	0.0032+ (0.0017)
2	-0.1090* (0.0521)	0.0074 (0.0062)	0.0089 (0.0155)	-0.0376 (0.0262)	0.0003 (0.0027)	0.0016 (0.0020)
3	-0.0700 (0.0501)	-0.0010 (0.0055)	-0.0008 (0.0175)	0.0047 (0.0306)	0.0041 (0.0028)	0.0024 (0.0022)
4	-0.0811 (0.0556)	0.0104+ (0.0061)	-0.0364* (0.0185)	-0.0205 (0.0288)	0.0019 (0.0031)	0.0029 (0.0021)
5	-0.0389 (0.0555)	0.0100 (0.0063)	-0.0267 (0.0196)	-0.0450 (0.0368)	0.0037 (0.0030)	0.0036+ (0.0022)
Control schools	-0.0507 (0.0450)	-0.0052 (0.0042)	0.0232+ (0.0134)	0.0094 (0.0187)	0.0016 (0.0018)	0.0020+ (0.0011)
N	11464	17242	19079	17242	20882	20881

Student composition: Share female, fathers' and mothers' education and earnings, immigrant background, birth cohort, school county X birth cohort

+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

Appendix 4. Fidelity

Teachers and school staff in schools implementing SWPBS complete The Effective Behavior Support Self-Assessment Survey (EBS, 46 items) annually, which measures *perceived* fidelity at the school level (18 items), at the classroom level (11 items), in individual cases (8 items), and in common areas like hallways and the playground (9 items) (Sørli & Ogden, 2015). The measure has shown high reliability in prior evaluation studies (e.g., Bradshaw et al., 2010; Sørli & Ogden, 2015), but no validation data have been published. The teachers rate how statements like “Expected student behavior is consequently encouraged and positively acknowledged” corresponded with their experiences by using a 3-point scale ranging from 1 (*in place*) to 3 (*not in place*). For SWPBS to be adequately implemented, a minimum 80% threshold score on the fidelity scale is considered necessary.

We have data on the EBS survey from 2008 and to 2014, and all schools that can complete the EBS survey in a given year are included. The EBS survey is on average completed by 21.6 number of teachers and school staff. However, our EBS data does not include individual responses, only school averages, and computing interrater reliability is accordingly not possible.

All schools should complete the EBS survey at least annually. Schools that do not complete the EBS survey in a given year after initiation are recorded as not implementing with fidelity. Approximately 13 percent of schools fail to complete the EBS survey the year of initiation and the year after initiation, and 10 percent of schools fail to complete the EBS survey two years after initiation. Three and four years after initiation, 27 percent of schools fail to complete the EBS survey, while almost 50 percent fail to complete the survey five years after initiation.

Table A4.1 Share of schools implementing with fidelity by year after initiation of SWPBS.

Years since initiation	N	Overall fidelity	Classroom	Individual	Non-Classroom	School-Wide
0	133	0.008	0.015	0.008	0.015	0.008
1	166	0.000	0.006	0.000	0.012	0.006
2	205	0.020	0.132	0.005	0.122	0.137
3	184	0.141	0.234	0.033	0.240	0.375
4	146	0.205	0.288	0.034	0.411	0.466
5	123	0.163	0.211	0.065	0.260	0.317

Note: Schools that do not complete the EBS survey in a given year after initiation are recorded as not implementing with fidelity. Different number of observations reflect that we do not have data on implementation prior to 2008 (e.g., schools that initiate SWPBS in 2006 is observed 2-5 years after initiation) and that some schools initiate SWPBS late (e.g., schools that initiate SWPBS in 2012 is observed 0-2 years after initiation).

Table A4.2 Correlations between the EBS-dimensions.

	Classroom	Individual	Non-Classroom	School-Wide
Classroom	1.000			
Individual	0.736***	1.000		
Non-Classroom	0.935***	0.748***	1.000	
School-Wide	0.905***	0.811***	0.909***	1.000

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure A4.1 Overall fidelity at the school level by year after initiation of SWPBS.

Note: Each circle represents the degree of fidelity for a SWPBS school (i.e., 0.40 means that 40% is in place). Only schools that complete the EBS survey in a given year is included. Year 0 indicates year of initiation.

Figure A4.2 Fidelity at the school level by year after initiation of SWPBS and subscale of fidelity. Note: Each circle represents the degree of fidelity for a SWPBS school (i.e., 0.40 means that 40% is in place). Only schools that complete the EBS survey in a given year is included. Year 0 indicates year of initiation.

In Figure 3 in the main text, we examined whether the effects of SWPBS were stronger for schools that implemented with high fidelity. More specifically, for each school that implemented SWPBS between 2008 and 2011 the average score were calculated for the classroom level, non-classroom level, and school-wide sub-scales from the EBS survey (excluding the individual level). Schools that within three years of implementation had an average score of 80% or more were considered implementing with fidelity, which was 62 of the schools (30%).

Next we estimated the intervention effect separately for high-fidelity schools and lower-fidelity schools, and plotted the results from the separate DiD models as shown in Figure 3. The results suggest that the intervention effects were rather similar for both; the confidence intervals overlapped and the point estimates were similar. However, because few schools implemented with fidelity, the results are imprecise and no strong conclusions can be drawn from the results.

Appendix 5. School heterogeneity illustrated by fixed effects distributions

Table A5.1 Average fixed effects difference between SWPBS schools and control schools across all cohorts.

	(1)	(2)
Classroom noise	-0.09155***	-0.02370***
Bullied	0.01034***	0.00048
Academic performance	0.00439	-0.00513
Well-being	-0.02859***	-0.00436
Pull-out instruction	0.00094	0.00185***
Special education	-0.00448***	0.00030
Student composition	No	Yes

Note: Results in column (1) are without any control variables while the results in column (2) includes the following student composition variables: Share female, fathers' and mothers' education and earnings, immigrant background, birth cohort, school county X birth cohort

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Figure A5.1 Distributions of school fixed effects, from column 2 in table A5.1.

Table A5.2 Effect estimates with less comprehensive designs.

	(1) Classroom noise	(2) Bullied	(3) Academic performance	(4) Well-being	(5) Pull-out instruction	(6) Special education
A. Case study						
1-5 years	0.0128 (0.0381)	-0.000412 (0.00432)	-0.0331* (0.0175)	-0.0372* (0.0219)	0.00545*** (0.00211)	0.0102*** (0.00180)
2-5 years	0.00188 (0.0388)	-0.00182 (0.00431)	-0.0359* (0.0183)	-0.0278 (0.0227)	0.00613*** (0.00221)	0.0112*** (0.00188)
N	787	1205	1350	1205	1414	1414
B. Control						
1-5 years	-0.0126 (0.0192)	0.0123*** (0.00257)	-0.0325*** (0.00968)	-0.0626*** (0.0140)	0.000906 (0.00225)	0.000489 (0.00217)
2-5 years	-0.0281 (0.0213)	0.0132*** (0.00264)	-0.0351*** (0.0104)	-0.0637*** (0.0147)	0.000915 (0.00237)	0.000314 (0.00223)
N	11305	16866	18664	16866	20467	20466

Note: Panel A is based on SWPBS schools only, comparing before and after implementation. Panel B contain only post-implementation years but compare SWPBS schools and control schools. Student composition: Share female, fathers' and mothers' education and earnings, immigrant background, birth cohort, school county X birth cohort

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Appendix 6. Response rate

Figure A6.1 Response rate differentials between SWPBS schools and control schools, by cohorts relative to the implementation year.

Appendix 7. Raw differences between SWPBS schools and control schools**Table A7.1** Differences between SWPBS schools and control schools without any control variables and fixed effects.

	(1) Classroom noise	(2) Bullied	(3) Academic performance	(4) Well-being	(5) Pull-out instruction	(6) Special education
Control schools	Reference category	Reference category	Reference category	Reference category	Reference category	Reference category
SWPBS before/after:						
-3	-0.0268 (0.0666)	0.0189** (0.00701)	0.00332 (0.0280)	-0.00332 (0.0340)	-0.00829* (0.00327)	-0.0113*** (0.00261)
-2	-0.0102 (0.0629)	0.0139* (0.00579)	-0.0200 (0.0272)	-0.0120 (0.0360)	0.00203 (0.00297)	-0.00824** (0.00260)
-1	-0.0933 (0.0479)	0.0110* (0.00477)	-0.00740 (0.0227)	-0.0291 (0.0259)	0.000869 (0.00289)	-0.00532* (0.00262)
1	0.0131 (0.0392)	0.0198* (0.00801)	-0.0300 (0.0204)	-0.0897*** (0.0262)	0.000903 (0.00263)	-0.00202 (0.00246)
2	-0.0766 (0.0404)	0.0233*** (0.00530)	-0.0229 (0.0230)	-0.0683* (0.0304)	0.00163 (0.00285)	-0.000779 (0.00245)
3	-0.0593 (0.0338)	0.00600 (0.00469)	-0.0211 (0.0221)	-0.0232 (0.0255)	0.00594* (0.00276)	0.00222 (0.00248)
4	-0.0428 (0.0325)	0.0130* (0.00560)	-0.0644** (0.0226)	-0.0315 (0.0246)	0.00385 (0.00283)	0.00387 (0.00250)
5	0.0125 (0.0360)	0.00883 (0.00563)	-0.0672** (0.0246)	-0.0476 (0.0250)	0.00593* (0.00297)	0.00642* (0.00259)
Constant	0.0204*** (0.00567)	0.0725*** (0.000718)	0.000745 (0.00670)	0.0715*** (0.00449)	0.0529*** (0.000670)	0.0702*** (0.000758)
Observations	11591	17374	19245	17375	21080	21079

Note: Cluster robust standard errors in parentheses.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$