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Research Article

Increasing immunization compliance among schools and day care centers: Evidence from a randomized controlled trial

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Abstract: This paper reports on the results of a randomized controlled trial in which researchers collaborated with a department of health in a mid-size city to evaluate the effectiveness of targeted communications highlighting descriptive social norms to increase immunization compliance across 700 schools. Schools were randomly selected to receive a twice-annual immunization compliance report card reporting in detail their compliance rates compared to other schools of the same school type; the comparison rates reported included the school-type average, average compliance among the top 10% of performers, and the city target of 98% compliance. Shifts in immunization compliance are tracked in a city-wide administrative vaccine registry. The results suggest that there was no significant difference in compliance rates between treatment and control schools six months post-treatment. To our knowledge, it is the first randomized controlled trial evaluating the use of descriptive social norms in increasing immunization compliance rates in a school-based setting. In addition, it serves as an example of embedding a behaviorally-informed experiment in a government program utilizing high-quality administrative data.

Keywords: Immunization compliance, School immunization policy, Social norms

Supplements: Open materials, Preregistration

Despite the fact that immunization rates for children and young adults in the United States have been and remain relatively high, declining immunization rates and the resurgence of infectious diseases pose increasing public health challenges. Recent evidence suggests that vaccine rates are high for infants and children entering kindergarten, but are lower and highly variable across states for adolescents. While vaccines are compulsory for school-aged children, vaccine hesitancy among parents and the use of non-medical vaccine exemptions has been increasing (Omer, Salmon, Orenstein, Dehart, & Halsey, 2009).

State-, city- and school-level variation in how school vaccination requirements are administered and communicated to school stakeholders as well as parents is hypothesized to be extremely salient in shaping local variation in immunization outcomes. Little systematic evidence exists, however, around the relationship between this policy variation and immunization outcomes (Wang, Clymer, Davis-Hayes, & Buttenheim, 2014). This stands in contrast to the large body of evidence and recommendations tailored for clinicians focused on increasing vaccine uptake (Sharts-Hopko, 2009). Moreover, while there is an increasingly large literature focused on the use of descriptive social norms to nudge behavioral change in a range of arenas (see Background below), up to this point, little evidence has been presented around the effectiveness of social norms in addressing compliance with vaccine guidelines in a school-based setting.

This paper reports on a randomized controlled trial conducted in collaboration with the department of health of a mid-size city (subsequently referred to as DOH) to evaluate the effectiveness of targeted communications highlighting descriptive social

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norms and designed to increase immunization compliance across 700 schools and day care centers. (For concision, we will henceforth refer to all educational sites in the evaluation, including day care centers, simply as schools.) Immunization compliance in this context is defined as the percentage of enrolled students reporting completion of all required vaccines for their age, or the documentation of an appropriate exemption under local law.

The evaluation included the full universe of schools in the city, and randomly selected half to receive a twice-annual immunization report card directed to the school leader (principal or day care director), reporting in detail the school's immunization compliance rates compared to other schools of the same school type (day care, elementary, middle, and high).

More specifically, the report card provided information about three social norms: descriptive information about average compliance and average compliance among the top 10% for the school category, and injunctive information conveyed in a star rating for the school's performance. In addition, the report card provided information about action steps school leaders could take to increase compliance rates, and a detailed list of the school's compliance rates for each required vaccine compared to the city target of 98% compliance. The vaccines listed are: diphtheria, DTaP, HPV, hepatitis A, hepatitis B, haemophilus influenzae type B, Hib-MenCY-TT, polio, MMR, measles, meningococcal, mumps, pneumococcal conjugate 7, pneumococcal conjugate 13, rubella, tetanus-diphtheria, Tdap, and varicella.

In order to evaluate the effects of the intervention, school-level immunization compliance rates were tracked over the year using the comprehensive city-level immunization registry, the Immunization Information System (IIS). The primary empirical specification then simply compares estimated compliance rates across the two experimental arms. The results suggest that the intervention did not lead to any statistically significant increases in immunization compliance. The coefficients of interest are small in magnitude, and allow us to rule out an increase in compliance larger than 2.8 percentage points, relative to an average compliance rate of 76%. There is similarly no evidence of heterogeneous effects for different school types, or different types of vaccines.

The observed null effect of the treatment suggests that the use of the report cards was not sufficient to generate significant shifts in immunization compliance. There are several potential channels that would be consistent with this pattern. School officials may not view immunization compliance rates as an important or salient objective; they may be poorly incentivized to enhance immunization rates, even if they view it as a meaningful objective; or they may lack appropriate levers to shift parental and household behavior around immunizations.

This project seeks to make a number of contributions to the literature. To our knowledge, it is the first randomized controlled trial evaluating the use of descriptive social norms in increasing immunization compliance rates in a school-based setting. In addition, it serves as an example of embedding a behaviorally-informed experiment in a government program: it included a large sample of schools (the full universe of schools in the collaborating jurisdiction), benefited from a close collaboration with the responsible health authorities, and utilized a high-quality administrative registry (rather than self-reports) to track immunization outcomes. The results suggest that further exploring the potential of targeted communications using social norms may be a valuable strategy for health policymakers.

From a public health perspective, this paper also joins a growing literature that argues that declining vaccine rates and increasing vaccine hesitancy pose a challenge that is not easily targeted by traditional communication strategies. A recent review notes that there is limited literature on evidence-based tools to target vaccine hesitancy, and more well-informed strategies at the community level are needed (McClure, Cataldi, & O'Leary, 2017). This project contributes by evaluating one communication method that targets a novel community entry point for vaccine-related interventions: schools and day care centers.

Background on Social Norms

The existing literature provides substantial evidence of the relevance of social norms for immunization decisions made by parents for their children and adolescents. Qualitative and quantitative evidence suggests a perception that immunization as a social norm is positively associated with the decision to vaccinate (Sturm, Mays, & Zimet, 2005; Daley, Crane, Chandramouli, Beaty, Barrow, Allred, Berman, & Kempe, 2006, Oraby, Thampi, & Bauch, 2014), and this is especially relevant for some parents who rely primarily on general social norms in vaccine decision-making (Brunson, 2013). Attitudes and beliefs around vaccine safety concerns have been found to contribute

substantially to underimmunization (Gust, Strine, Maurice, Smith, Yusuf, Wil-kinson, Batta, Wright, & Schwartz, 2004). The positive effect of physician recommendations on immunization uptake has also been interpreted as evidence that vaccination interventions would benefit from enhancing social norms (Gargano, Herbert, Painter, Sales, Morfaw, Rask, Murray, DiClimente, & Hughes, 2013).

By contrast, there is very limited literature around the use of report card interventions seeking to deploy social norms to enhance immunization behavior. While immunization report cards have been used for schools in Oregon and Washington State, for parents in Oregon, and for county Departments of Health in Michigan, their use has not been evaluated.[1] Report cards on immunization rates were distributed to health practices in northern Manhattan as part of a broader intervention targeting zero to three-year old immunization rates in the area, and quasi-experimental analysis suggests that the intervention was successful in increasing immunization rates (Findley, 2003). For adult immunizations, healthcare providers who received feedback that compared their performance to top physicians increased flu vaccination rates from 40% to 58% (Kiefe, Allison, Williams, Person, Weaver, & Weissman, 2001).

A broad literature in other domains suggests that report cards or other interventions utilizing descriptive social norms can be effective in stimulating behavioral change: for example, social norms can be effective in stimulating more efficient energy use (Allcott, 2011, Ayers, 2013), reducing college-age drinking (Lewis & Neighbors, 2006), increasing rates of voter participation (Gerber & Rogers, 2007), and increasing compliance with environmental regulations (Cialdini, 2007).

In education, school-level report cards are becoming increasingly common signals of academic quality within state-level accountability systems. Scholars have connected these school-level report cards to gains in mathematics performance (Carnoy & Loeb, 2002), increases in voluntary or private contributions to schools (Figlio & Kenny, 2009), college going behaviors (Deming, Cohodes, Jennings, & Jencks, 2016), and the mobility of students and teachers (Clotfelter, Ladd, Vigdor, & Diaz, 2004). However, while school accountability systems do induce school leaders to take new actions in line with the goals that are being measured (Ladd & Zelli, 2002), existing evidence generally suggests that enhanced program outcomes are due to the incentives and sanctions built into many school accountability systems, rather than report cards alone (Hanushek & Raymond, 2004).

Context

This evaluation was conducted as a collaboration between the Office of Evaluation Sciences (an interdisciplinary team in the U.S. General Services Administration that translates evidence-based insights into concrete recommendations for how to improve government and tests to learn what works), and the immunization program in the department of health in a mid-size city. The collaborating department of health (DOH) has responsibility for overseeing immunization compliance rates within all educational institutions in the city, including day care centers and elementary, middle, and high schools (public, private, parochial, and charter).

City law requires all students enrolled in any educational institution to provide evidence that they have received all required immunizations, or provide documentation of a medical or religious exemption. Students in grades 6-12 are additionally required to provide documentation of receipt of the human papillomavirus (HPV) vaccine, or submit an opt-out form each year. The DOH also administers the city Immunization Information System (IIS), a registry that stores immunization records for children and adults in the city, tracks immunization compliance, and provides immunization data and reports.

Relative to national averages reported by the CDC, the city performs relatively poorly on vaccination rates for infants and students entering kindergarten (CDC 2018a, 2018b). However, vaccination rates for adolescents 13-17 are generally higher than the national average, particularly for HPV; nationwide averages for female and male adolescents who have received at least one HPV shot are 60.0% and 41.7%, respectively (Reagan-Steiner, 2015). (While this data is illustrative in comparing the city to national averages, it should be noted that it does not take into account requested exemptions, and thus is not directly comparable to the city's own internal measure of immunization compliance.)

Prior to this evaluation, all educational institutions received weekly automated email updates generated by the IIS, reporting overall compliance for the school; these updates were sent to the immunization point-of-contact, generally the school nurse for elementary, middle, and high schools, or the director for day care centers. The DOH uses two injunctive

Table 1
Summary Statistics for Immunization Compliance at Baseline, Midline, and Endline (all schools reporting)

	Baseline (October 2017)			Midline (April 2018)			Endline (July 2018)		
School type	Num. of schools	Mean	Top 10%	Num. of schools	Mean	Top 10%	Num. of schools	Mean	Top 10%
Day care	396	83.5	100.0	385	79.7	100.0	424	80.1	100
Elem.	126	81.6	90.4	123	83.0	93.3	126	83.2	94
Middle	46	67.5	82.7	37	63.7	85.9	46	58.2	78.5
High	37	60.3	79.0	46	62.1	83.1	37	60.7	74.7
Other	95	66.0	85.8	97	68.9	89.1	96	66.2	86.3
All	700	82.7	99.5	688	76.8	97.2	729	76.2	97.0

Notes: This table reports statistics by school type in the baseline and endline sample, including the number of schools, the mean compliance rate, and the mean compliance rate within the top 10% of high-performing schools. The sample is smaller for the midline data due to an error in the contemporaneous data request in which some schools were reported as zero enrollment.

norms to motivate compliance: first, the city has set a target of 98% immunization compliance for every school in the city. Second, to signify approval of immunization compliance at different compliance levels, each school is also assigned an immunization star rating of one to five stars, coded as follows: one star corresponds to zero compliance; two stars corresponds to compliance between zero and 75%; three stars corresponds to compliance between 75% and 90%; four stars corresponds to compliance between 90% and 98%; and five star schools have met or exceeded the 98% compliance rate. While DOH staff were also available to interact with school staff and immunization points of contact with questions about immunization policy on an ongoing basis, there was no other form of targeted communication around immunization directed to schools.

For the purpose of this intervention, immunization compliance rates at the school level were measured in October 2017, immediately prior to the rollout of the intervention. At this point, the DOH supervised a universe of 700 educational schools including 396 day care centers, 126 elementary schools, 37 middle schools, 46 high schools, and 95 schools classified for the purposes of this evaluation as "other" given that they included a range of grade levels spanning multiple school types. (For example, a school including students from grades six to twelve served by a single principal and a single immunization point-of-contact would be classified in the "other" category.)

Average immunization compliance rates as well as the compliance rates among the top 10% of schools for each school type are reported in Table 1. These summary statistics are reported for baseline (October 2017), midline (April 2018) and endline (July 2018), and are calculated including all schools for which compliance rates are reported in each data wave. In other words, the calculation is not restricted to the subsample of schools that can be matched across waves.

Compliance rates are highest for day care centers and elementary schools; the lower mean compliance rates for middle, high, and other schools primarily reflects much lower compliance rates for the HPV vaccine. The HPV vaccine became mandatory for female students in the city as of 2009 and for male students as of 2014, though parents may also comply with the requirement by submitting an opt-out form. It is also evident that in aggregate, vaccine compliance rates were roughly stable over the year, though they declined sharply for middle schools.

Experimental Design

In order to facilitate more rapid progress toward the target immunization compliance rates, DOH and the research team collaborated to design a report card

utilizing descriptive social norms around immunization compliance rates, an intervention that was randomly rolled out to school leaders in the 2017-28 school year. The report card was designed to address several barriers identified by DOH as important in limiting progress toward school-level immunization goals. First, immunization compliance may not be particularly salient to school leaders given their wide areas of responsibility. Second, school leaders may lack information about their students' current immunization status and appropriate steps to take to increase compliance rates. Third, they may not perceive that immunization compliance is an important objective, or may assume that their school's rates are already satisfactory.

The report card (shown in Appendix A) was designed to target each of these three barriers. The material was directed explicitly to the school leader (principal or day care director). The introduction sought to emphasize that school immunization is an important priority and high compliance rates can facilitate students' attendance and ensure that they are ready to learn. In addition, the report card provided detailed information about school-level compliance rates. The first page reported the average compliance rate for the school in a bar graph format as well as the school's star rating, while the second page reported enrollment rates by vaccine type, highlighted the vaccine type with the lowest compliance rate, and also highlighted the number of students (relative to total enrollment) who were out of compliance. Finally, several concrete action steps were suggested for school leaders. These included ensuring each student had a current health certificate on file, meeting with the school nurse or immunization point-of-contact to review compliance rates, and contacting the DOH Immunization Program as needed.

Perhaps most importantly, the report cards sought to harness descriptive social norms to generate urgency around the goal of increasing vaccine compliance. More specifically, the report card reported both the average compliance rate among all schools in the same category, and the average compliance rate among the top 10% of schools in that category. The objective was to emphasize that high levels of compliance were achievable and encourage underperforming schools to match these higher rates. At the same time, the use of the star rating, in addition to being consistent with the DOH's pre-existing ranking system, served as an injunctive norm to recognize the achievements of current high performers and eliminate any possible "boomerang effect" in which high performers would exhibit a deterioration of their performance (Schultz, 2007). The report cards were generated in Tableau, enabling the automatic personalization of each report card using school-specific information.

It should be noted that the report card sought to combine multiple cues around social norms, as well as multiple visualizations of those cues, in order to increase the probability that the intervention effectively generated increased compliance. There were three primary cues provided about social norms: the descriptive information about average compliance and average compliance among the top 10%, and the injunctive information conveyed in the star rating. The objective of including multiple cues was to enlarge the set of schools who would perceive some urgency in increasing their compliance rates: those below the average would immediately note the need to improve, while those above the average and below the 90% percentile would still be motivated by the comparison to high performers. The injunctive norm was included to minimize the probability of decreased compliance in high performing schools, as noted above. Each cue was then conveyed both visually and in text form to accommodate individuals with different preferences for the presentation of information; those who found the visual presentation more compelling could focus on the graphics, while readers seeking more information could utilize the text. Clearly there is some risk that the multiple presentations of information could be confusing or overwhelming, rendering the more comprehensive report card less effective. However, stakeholders believed that in this case, the benefits of including multiple informational cues outweighed this risk.

This intervention then relies on school leaders utilizing the information they were provided via the report card—and being newly motivated to utilize this information—in order to take actions to effectively inform parents about required immunizations and encourage them to update immunizations. Parents can ensure their children are up to date with required immunizations and receive up-to-date immunizations when needed. Any shifts in immunization status would be reported by physicians via the immunization information system.

Randomization was conducted by the research team using Stata, and was stratified by school type. 346 schools were randomized into the treatment arm, and 354 into the intervention arm. Balance tests were conducted by regressing baseline enrollment and baseline compliance rates on a dummy for treatment,

conditional on strata fixed effects; the results, reported in Appendix Table B1, suggest that the hypothesis of baseline balance on covariates comparing across treatment and control schools cannot be rejected.

Schools assigned to the intervention arm received the first report card in early November 2017, and the second report card in April 2018. The first report card was timed to reflect immunization compliance rates that were current around the point that school enrollment generally stabilizes for the year (more specifically, compliance rates were measured on October 17, 2017). The second report card was timed to enable schools to conduct further outreach to parents around the period of spring break and during the final months of the school year, using compliance rates measured on April 3, 2018. All schools in both treatment and control groups continued to receive weekly automated updates from IIS directed to the immunization point-of-contact.

Data and Analysis

The primary outcome variable for this evaluation is immunization compliance rate at the school level; the secondary outcome variable is the HPV compliance rate as observed for middle and high schools. (This rate was identified as a secondary outcome given that HPV compliance rates are observed to be low, and the HPV vaccination requirement is relatively new.) The researchers registered the trial in the American Economic Association trial database (AEARCTR-0002486) and pre-committed to an analysis plan posted online consistent with the Office of Evaluation Sciences Evaluation Policy. All outcome variables of interest are reported at the school level.

Given the experimental design, the regression of interest is simple. The dependent variable Yi for school is regressed on a dummy variable for treatment, and dummy variables for each school type / strata.

$$Yi = \beta Ti + \lambda i + \varepsilon i$$

We will also estimate additional specifications including controls for baseline school characteristics: school size, dummy variables for neighborhood, school type (private, public, parochial, or charter) and schools' initial relative standing in terms of immunization compliance rates. The latter variable is measured as the baseline level of immunization compliance, as well as a dummy variable for schools that are above and below the school type-specific mean comparison level.

While 700 schools were included in the baseline sample employed in randomization, there is some attrition over the year due to changes in operations or school closings; this is overwhelmingly a phenomenon observed for day care centers. Table 2 summarizes observed patterns of attrition; 36 schools from the original sample attrited over the year, 33 of which were day care centers. (The table also notes the number of new schools observed opening over the year; they are excluded from the analysis.) The final sample for analysis thus includes 664 schools that can be matched between the baseline sample in October 2017 and the endline sample observed in July 2018. Within this analysis sample, 33% of schools had two or fewer stars at baseline; 43% were rated three stars, 15% were rated four stars, and 9% were rated five stars.

The primary results are reported in Table 3. Column (1) reports the treatment effect for the full sample of schools, and Columns (3) through (7) report estimated treatment effects for each school type. Column (2) drops the 10% of schools exhibiting the lowest enrollment levels. The 10% of schools reporting low enrollment levels report enrollment of fewer than seven students; 17 are day care centers that may be accurately reporting low enrollment numbers, and 7 are elementary or "other" type schools that are presumably reporting low enrollment with some error. The coefficients of interest are uniformly insignificant, and in some cases negative.

Tables 4 and 5 report the same specifications estimated using additional control variables. All specifications now include dummy variables for school management type (public, private, or charter), as well as zip code fixed effects. Specifications in Table 4 additionally include controls for the baseline compliance rate, while specifications in Table 5 include a dummy variable for whether the school was above or below the school type-specific mean at baseline (i.e., the average compliance rate reflected in the first report card). Again, we observe a consistent pattern of null effects. In separate results not reported for concision, we also examine whether there is any evidence of heterogeneous effects with respect to the baseline star rating, and find there is no evidence of any such heterogeneity.

Another hypothesis that we explore is that the "reputational risk" carried by a low rating on immunization compliance is more significant for schools that are rated poorly along other, academic dimen-

Table 2
Sample and Attrition, by School Type

	Day care	Elementary	Middle	High	Other	Total
Baseline sample (Oct 2017)	396	126	46	37	95	700
Endline sample (July 2018)	363	126	45	36	94	664
Attrited	33	0	1	1	1	36
New schools	61	0	1	1	2	65

Notes: This table reports the number of schools of each type observed in the baseline and endline sample, as well as the number of schools that attrited from the sample and the number of new schools observed.

Table 3
Primary Results

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Full sample	Restricted enrollment	Day care	Elementary	Middle	High	Other
Report card	0.271	-0.244	1.453	-0.414	-4.374	-4.013	0.45
	(1.307)	(1.253)	(1.805)	(2.281)	(4.971)	(4.245)	(4.365)
Confidence intervals	[-2.295, 2.836]	[-2.705, 2.217]	[-2.097, 5.003]	[-4.929, 4.100]	[-14.467, 5.719]	[-12.569, 4.543]	[-8.219, 9.118]
Mean compliance	76.234	76.643	80.145	83.194	58.154	60.661	66.186
N	664	629	363	126	36	45	94

Notes: The specification of interest regresses immunization compliance rates at the school level on a dummy for the report card treatment, conditional on school type fixed effects. The sample is as reported for each column; the restricted enrollment sample includes only schools reporting enrollment above 10% at baseline. Standard errors are reported in parentheses.
*** p<0.001, ** p<0.01, * p<0.05

sions. Schools in this city are rated by the state on a system of one to five stars capturing their overall academic performance, and this data is available for public and charter schools; a parallel rating is not available for day cares, or for private schools. We can re-estimate treatment effects including a control variable for academic star rating for the subsample of public and charter schools; these results are reported in Table B2 in the Appendix, and again show a null effect of the treatment.

Table 6 reports treatment effects for the HPV vaccine compliance rate for the subsample of middle and high schools. Again, there is no evidence of significant effects for the HPV compliance rates.

Finally, Tables B3 and B4 in the appendix report robustness checks in which we evaluate if the treatment stimulated any differential shifts in reported enrollment, or in attrition from the sample. In particular, one possible response for schools receiving a report card would be to ensure that their enrollment rosters are appropriately updated, to avoid compliance rates that are artificially low due to students no longer enrolled in the same school. Similarly, day care centers that are in fact no longer open may update their enrollment rosters (to reflect zero enrollment) upon receiving a report card that erroneously reports positive enrollment.

We observe that while there is no significant effect on reported enrollment on average, there is a significantly higher rate of attrition observed among day care centers in the treatment arm; in fact, the attrition rate more than doubles, from 5% to nearly 12%. Receipt of the report cards does appear to encourage day care directors and some other school leaders to update relevant administrative information in cases in which they are in fact no longer open. (Approximately half of the attrited day care centers had enrollment of less than 12 students reported at baseline in October, suggesting it is plausible that they were already in the process of closing their doors, and/or were erroneously reporting non-zero enrollment at a point when they had already closed.)

Table 4
Primary Results Controlling for Baseline School Characteristics and Compliance

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Full sample	Restricted enrollment	Day care	Elementary	Middle	High	Other
Report card	-0.202	-0.399	-0.313	0.963	-6.325	-2.134	1.656
	(0.907)	(0.893)	(1.441)	(1.770)	(5.101)	(2.176)	(2.377)
Confidence intervals	[-1.983, 1.579]	[-2.152, 1.354]	[-3.147, 2.521]	[-2.540, 4.467]	[-16.680, 4.031]	[-6.519, 2.250]	[-3.065, 6.376]
Mean compliance	76.234	76.643	80.145	83.194	58.154	60.661	66.186
N	664	629	363	126	36	45	94

Notes: The specification of interest regresses immunization compliance rates at the school level on a dummy for the report card treatment, conditional on school type fixed effects, dummies for school management type (public, private, or charter), zip code fixed effects, and a control variable for baseline compliance. The sample is as reported for each column; the restricted enrollment sample includes only schools reporting enrollment above 10% at baseline. Standard errors are reported in parentheses.
*** p<0.001, ** p<0.01, * p<0.05

Table 5
Primary Results Controlling for Baseline School Characteristics and Compliance above / below Mean at Baseline

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Full sample	Restricted enrollment	Day care	Elementary	Middle	High	Other
Report card	-0.127	-0.358	-0.188	1.066	-4.163	-2.643	1.347
	(0.909)	(0.893)	(1.432)	(1.81)	(4.188)	(2.524)	(2.396)
Confidence intervals	[-1.912, 1.657]	[-2.111, 1.395]	[-3.005, 2.629]	[-2.518, 4.649]	[-12.665, 4.338]	[-7.729, 2.444]	[-3.412, 6.106]
Mean compliance	76.234	76.643	80.145	83.194	58.154	60.661	66.186
N	664	629	363	126	36	45	94

Notes: The specification of interest regresses immunization compliance rates at the school level on a dummy for the report card treatment, conditional on school type fixed effects, dummies for school management type (public, private or charter), zip code fixed effects, and a control variable for whether the school's compliance rate is above or below the school type-specific mean at baseline. The sample is as reported for each column; the restricted enrollment sample includes only schools reporting enrollment above 10% at baseline. Standard errors are reported in parentheses.
*** p<0.001, ** p<0.01, * p<0.05

Table 6
Secondary Results: HPV Vaccine

	Middle schools	High schools
Report card treatment	-6.438	-4.126
	(4.672)	(4.069)
Confidence intervals	[-15.922, 3.046]	[-12.326, 4.074]
Compliance rate	63.139	63.591
N	36	45

Notes: The specification of interest regresses the immunization compliance rate at the school level for the HPV vaccine on a dummy for the report card treatment, conditional on school type fixed effects. The sample is as reported for each column; standard errors are reported in parentheses.
*** p<0.001, ** p<0.01, * p<0.05

Discussion and Conclusion

To briefly summarize the goals of the report card intervention, the objective was to address three postulated barriers that could negatively affect school vaccine compliance: limited salience of immunization goals, limited information, and the perception that immunization compliance is not an important goal, or not relevant for a particular school. The report cards sought to encourage enhanced immunization compliance by deploying both descriptive and injunctive social norms.

The absence of any significant effect of the report cards provided on immunization compliance outcomes suggests that the intervention did not effectively address the hypothesized barriers. One potential explanation for the null effect is that the salience of the report cards to school leaders was low, particularly since this was a new intervention; they may have regarded the communication as of limited importance or irrelevant to their role. In this case, the intervention may have failed to effectively address the barriers of limited salience and limited information.

As noted above, however, there is some evidence that day care directors are at least partially responsive, in that those who receive the report cards seem more likely to report a closure of the day care. In addition, anecdotal evidence from the DOH suggests that some school leaders and school nurses responded to the receipt of report cards by following up with DOH staff; their objective was generally to receive more information about the data or note that their current compliance rates were not identical to those included in the report card, since the report card reflected a snapshot of compliance rates on a particular day. Accordingly, it does not seem that the report cards were simply ignored on a large scale.

Alternatively, it may be that the key barrier to enhanced immunization was the third barrier identified here – the perception that immunization compliance is not an important goal for school leaders – and the intervention failed to shift this perception. It is important to note that school leaders face essentially no incentives to enhance compliance rates, and are much more likely to be evaluated along other metrics, both by their own superiors and by parents. Particularly in schools with a school nurse, the school leaders may view the primary party responsible for compliance to be the nurse. While the report cards were designed to generate a sense of internal pressure based on social norms, this may not suffice given that the information in the report cards is not public, while a host of other measures of school leader performance are both public and highly salient. As previously noted, existing literature generally concludes that incentives and sanctions are an essential prerequisite for generating enhanced program outcomes, rather than report cards alone (Hanushek & Raymond, 2004); the absence of any incentives in this case may have rendered the report cards of limited effectiveness.

Finally, it is also useful to highlight that our intervention did not in any way target another potentially important barrier: school leaders' limited ability to influence immunization compliance. In practice, even motivated school leaders may not be able to significantly shift families' immunization behavior; while they can review detailed registry information and communicate with parents, they are not empowered to penalize parents or students who are not in compliance. Accordingly, the school leader may not

be able to identify or access any levers that directly alter parents' immunization choices. In this case, the intervention may have been successful in stimulating additional commitment to immunization compliance on the part of school leaders, without generating a measurable increase in compliance in the data. Unfortunately, the research design did not allow us to directly measure school leader effort.

A related point here is that the timeline for detecting effects on immunization compliance is relatively short. DOH hypothesized that the reasonable horizon for detecting an effect of the intervention was within the same academic year; enrollment shifts substantially from year to year, and thus in the new year school leaders would have to re-focus on immunization compliance for a new set of students, and thus presumably would no longer be responding to information previously shared about last year's enrollment. Given the time required to assemble and distribute the initial report cards in November, this allowed for a window of about 6-7 months for school leaders to respond to the first report card and generate a detectable effect on immunization compliance; the window for the second report card was much shorter, only about 2-3 months. Given that immunization compliance shifts over time, however, it is plausible to hypothesize that the response window to an intervention such as report cards is in fact relatively short, and that school leaders are unlikely to respond to (now outdated) information beyond the period for which data was available in this analysis.

From a broader policy perspective, this evaluation illustrates how state immunization information systems can provide school-level data on immunization rates to school leaders as well as comparative immunization rates across a set of peer schools. In addition, the evaluation demonstrates the feasibility of automating the creation of personalized report cards at the school level, even for non-traditional (i.e., not strictly academic) metrics.

This project also provides insights about the potential of targeted communications using social norms as a strategy for health policymakers. The evidence presented here suggests that while report cards utilizing cues around social norms of immunization may be a valuable part of an overall strategy to increase immunization compliance rates or compliance with other school health goals, this strategy may not suffice in an environment where school officials face explicit incentives along many other dimensions of performance. Ultimately, the motivational effects of social comparisons may be muted in a context in which key stakeholders receive a diverse array of feedback regarding a range of educational and health goals. Regardless, schools may constitute a valuable entry point for communications with parents, including parents who have a wide range of attitudes toward vaccines and different patterns of interaction with the health system. Collaborating with school systems to share health information and health communications around vaccines may be a useful tool for policymakers.

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Notes

1. The Oregon School and District Report Cards, administered by the state's Department of Education, include school profile information about immunization rates (https://www.oregon.gov/ode/schools-and-districts/reportcards/reportcards/Pages/Report-Card-How-to-Read.aspx). The Washington State Department of Health provides annual School Immunization Reports (https://www.doh.wa.gov/DataandStatisticalReports/HealthBehaviors/Immunization/SchoolReports), which some school districts have adapted into Report Cards (https://www.ohsd.net/cms/lib09/WA01919452/Centricity/Domain/15/3566_Olympic%20View%20Elem.pdf). The Michigan Department of Health & Human Services makes a County Immunization Report Card available by county, each quarter (https://www.michigan.gov/mdhhs/0,5885,7-339-73971_4911_4914_68361-321114--,00.html). All retrieved on August 19, 2018.

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Appendix

Appendix A. Report Card Example for a Middle School

FRONT

[redacted] HEALTH

Dea [redacted]

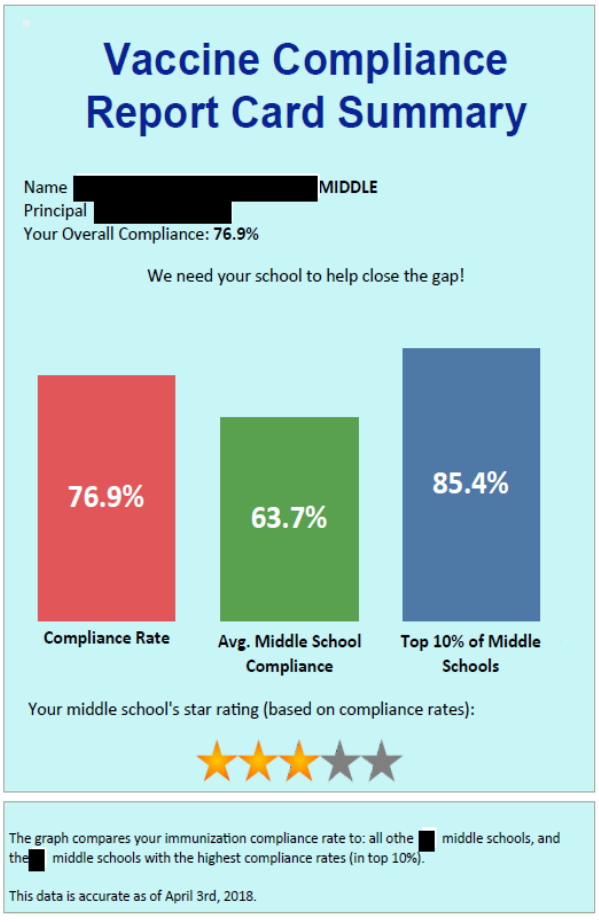
I hope you are having a great school year! The [redacted] Department of Health [redacted] is mailing this immunization report card to provide a point-in-time picture of your Middle school's immunization compliance rates.

Why is this important?
Middle schools with low immunization compliance rates are at a higher risk of a disease outbreak which forces both sick and under-immunized students to stay home. In addition, a student who is not fully immunized may be missing out on other critical health care services. You are the key to protecting your students from vaccine-preventable disease and ensuring they are healthy and ready to learn.

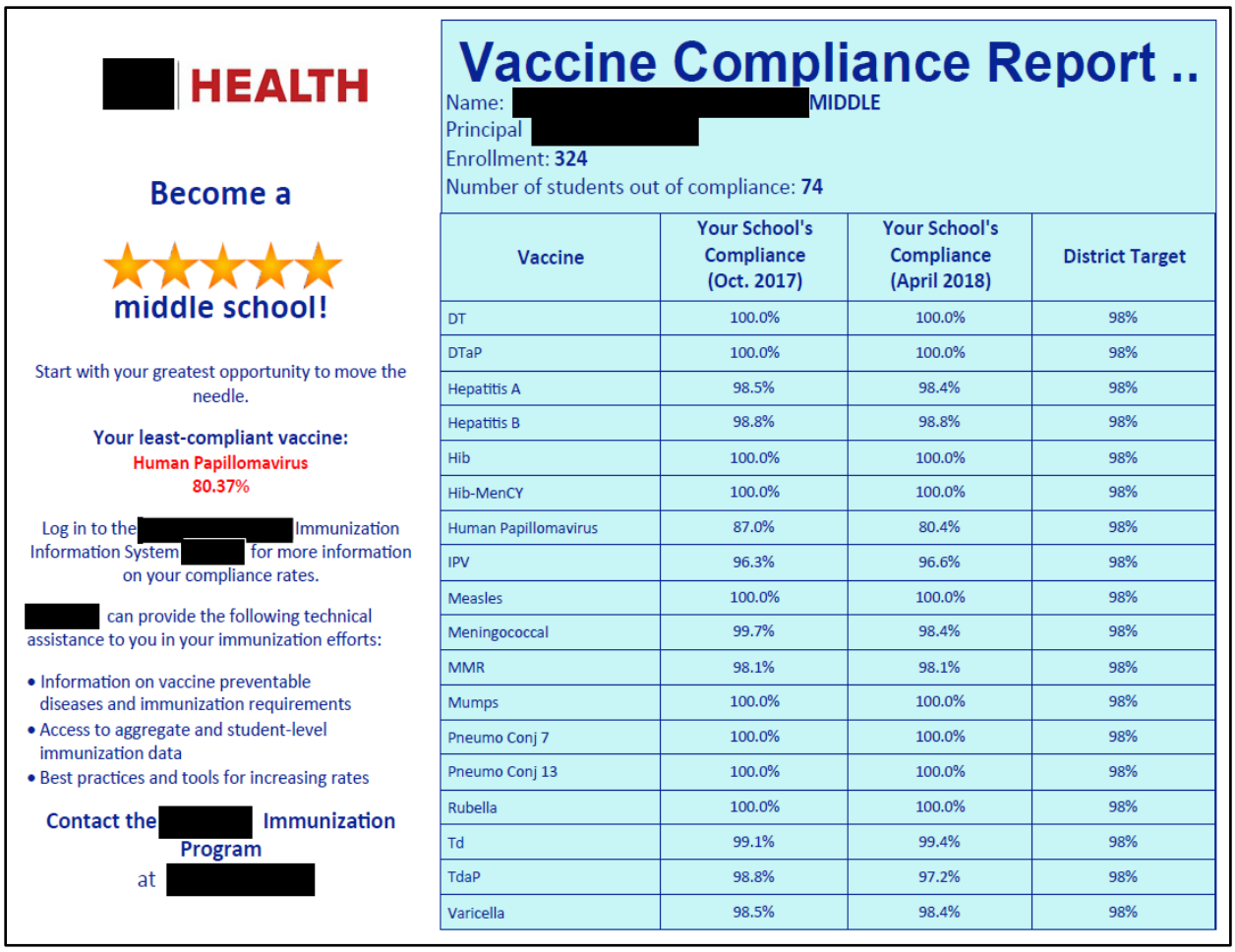
How can I take action?

1. Ensure each student has a current **Universal Health Certificate** on file.
2. **Meet with your school nurse or immunization point of contact** to review your detailed compliance rates.
3. **Contact** [redacted] at [redacted] or [redacted] for more information.

Thank you for your ongoing commitment to your students!
[redacted] **Immunization Program**



BACK(next page)



[redacted] HEALTH

Become a

middle school!

Start with your greatest opportunity to move the needle.

Your least-compliant vaccine:
Human Papillomavirus
80.37%

Log in to the [redacted] Immunization Information System [redacted] for more information on your compliance rates.

[redacted] can provide the following technical assistance to you in your immunization efforts:

- Information on vaccine preventable diseases and immunization requirements
- Access to aggregate and student-level immunization data
- Best practices and tools for increasing rates

Contact the [redacted] Immunization Program
at [redacted]

Vaccine Compliance Report ..

Name: [redacted] MIDDLE
Principal [redacted]
Enrollment: **324**
Number of students out of compliance: **74**

Vaccine	Your School's Compliance (Oct. 2017)	Your School's Compliance (April 2018)	District Target
DT	100.0%	100.0%	98%
DTaP	100.0%	100.0%	98%
Hepatitis A	98.5%	98.4%	98%
Hepatitis B	98.8%	98.8%	98%
Hib	100.0%	100.0%	98%
Hib-MenCY	100.0%	100.0%	98%
Human Papillomavirus	87.0%	80.4%	98%
IPV	96.3%	96.6%	98%
Measles	100.0%	100.0%	98%
Meningococcal	99.7%	98.4%	98%
MMR	98.1%	98.1%	98%
Mumps	100.0%	100.0%	98%
Pneumo Conj 7	100.0%	100.0%	98%
Pneumo Conj 13	100.0%	100.0%	98%
Rubella	100.0%	100.0%	98%
Td	99.1%	99.4%	98%
TdaP	98.8%	97.2%	98%
Varicella	98.5%	98.4%	98%

Appendix B. Additional Tables

Appendix Table B1
Baseline Balance Test

	Baseline enrollment	Baseline compliance rates
Report card	-5.705	.241
	(12.810)	(1.299)
Confidence intervals	[-30.813, 12.298]	[-2.305, 1.247]
Mean dep. var.	166.693	78.441
N	700	700

Notes: The specification of interest regresses total enrollment and immunization compliance rates as observed at baseline at the school level on a dummy for the report card treatment, conditional on school type fixed effects. Standard errors are reported in parentheses.
*** p<0.001, ** p<0.01, * p<0.05

Appendix Table B2
Treatment Effects Conditional on Academic Star Rating

	Full sample	Elementary	Middle	High	Other
Report card	0.397	1.709	-5.461	-0.568	4.045
	(1.716)	(2.718)	(5.011)	(3.03)	(2.939)
Confidence intervals	[-2.989, 3.782]	[-3.690, 7.108]	[-15.695, 4.773]	[-6.766, 5.630]	[-1.894, 9.984]
Mean compliance	75.210	83.208	60.789	64.151	75.341
N	193	91	31	30	41

Notes: The specification of interest regresses enrollment at the school level on a dummy for the report card treatment, conditional on school type fixed effects and a control for the school's star rating. The sample is as reported for each column, but is restricted to public and charter schools that could be matched to the academic star ratings reported by the city. The sample of 664 schools include 230 public and charter schools above the day care level, of which 37 could not be matched to the academic star ratings, yielding a sample of 193 observations. Standard errors are reported in parentheses.
*** p<0.001, ** p<0.01, * p<0.05

Appendix Table B3
Treatment Effects on Enrollment

	Full sample	Restricted enrollment	Day care	Elementary	Middle	High	Other
Report card	2.386	-1.188	4.309	12.044	-27.328	72.022	-39.956
	(12.062)	(12.466)	(4.002)	(29.460)	(79.271)	(94.158)	(49.676)
Confidence intervals	[-21.301, 26.074]	[-25.672, 23.295]	[-3.562, 12.180]	[-46.271, 70.358]	[-188.257, 133.600]	[-117.741, 261.784]	[-138.616, 58.705]
Mean enrollment	176.988	186.580	43.848	337.000	325.306	425.311	300.968
N	664	629	363	126	36	45	94

Notes: The specification of interest regresses enrollment at the school level on a dummy for the report card treatment, conditional on school type fixed effects. The sample is as reported for each column; the restricted enrollment sample includes only schools reporting enrollment above 10% at baseline. Standard errors are reported in parentheses.
*** p<0.001, ** p<0.01, * p<0.05

Appendix Table B4
Treatment Effects on Attrition

	Full sample	Restricted enrollment	LCDCs	Elementary	Middle	High	Other
Report card	0.040**	0.041**	0.066**	0	-0.05	0.042	0.021
	(0.017)	(0.017)	(0.028)	(0)	(0.050)	(0.042)	(0.021)
Confidence intervals	[0.007, 0.073]	[0.006, 0.075]	[0.010, 0.121]	[0.000, 0.000]	[-0.152, 0.052]	[-0.042, 0.126]	[-0.021, 0.064]
Mean attrition	.051	.054	.083	0	.027	.022	.011
N	664	629	363	126	36	45	94

Notes: The specification of interest regresses a dummy for attrition at the school level on a dummy for the report card treatment, conditional on school type fixed effects; the attrition dummy is defined equal to one if the school does not appear in the endline sample. The sample is as reported for each column; the restricted enrollment sample includes only schools reporting enrollment above 10% at baseline. Standard errors are reported in parentheses.
*** p<0.001, ** p<0.01, * p<0.05