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Teacher Evaluation and Teacher Turnover, New Evidence from District of Columbia Public Schools

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Few topics in education policy have received more attention than teacher turnover—and rightly so. The cost of losing a good teacher can be substantial and is born most directly by students. It is now widely recognized that teachers differ considerably in their ability to improve student outcomes, but discussions of teacher turnover rarely reflect these differences. Instead, we typically treat teacher turnover as uniformly negative. In this paper, we examine teacher turnover in the context of rigorous teacher evaluation to explore three questions. How does teacher turnover affect the quality of teaching and student achievement? How does teacher turnover vary by measured teaching effectiveness? And to what extent is the turnover of effective teachers associated with the evaluation system? We examine these questions employing data from the District of Columbia Public Schools. We find that in general turnover improves teacher quality and student achievement, but that this result masks large differences between teachers identified as more and less effective. Turnover among more effective teachers is relatively low, and when more-effective teachers exit, they infrequently report the evaluation system as a reason.

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Abstract. Few topics in education policy have received more attention than teacher turnover—and rightly so. The cost of losing a good teacher can be substantial and is born most directly by students. It is now widely recognized that teachers differ considerably in their ability to improve student outcomes, but discussions of teacher turnover rarely reflect these differences. Instead, we typically treat teacher turnover as uniformly negative. In this paper, we examine teacher turnover in the context of rigorous teacher evaluation to explore three questions. How does teacher turnover affect the quality of teaching and student achievement? How does teacher turnover vary by measured teaching effectiveness? And to what extent is the turnover of effective teachers associated with the evaluation system? We examine these questions employing data from the District of Columbia Public Schools. We find that in general turnover improves teaching quality and student achievement, but that this result masks large differences between teachers identified as more and less effective. Turnover among more effective teachers is relatively low, and when more-effective teachers exit, they infrequently report the evaluation system as a reason.

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Few topics in education policy have received more attention than teacher turnover—and rightly so. The cost of losing a good teacher can be substantial and is born most directly by students. Too often, the students who are most affected are poor and nonwhite; these are the students for whom teacher turnover is greatest and for whom receiving an effective replacement teacher is least likely. This is not, however, a concern for high-poverty schools alone, nor is it a recent phenomenon. The influence of teacher turnover in education policy extends well beyond teacher labor markets, to teacher preparation, school finance, accountability, and school leadership, leading policymakers to embrace a variety of proposals to mitigate teacher turnover.

Everyone agrees, therefore, that schools should make substantial efforts to retain good teachers, and that current efforts are often insufficient. Most would also agree that an ineffective teacher who shows promise should receive supports to facilitate progress toward effectiveness. In addition, most would agree that, in the absence of such progress, ineffective teachers should not be entrusted with the education of children. The cost is too high. While most observers agree with these statements conceptually, discussions of teacher turnover rarely are so nuanced. Instead, we typically treat teacher retention as unambiguously favorable (Ingersoll, 2001; National Commission on Teaching and America's Future, 2003; Carver-Thomas & Darling-Hammond, 2019).

More telling, there is a lack of discussion around the potential impact of differential retention for students. Several years ago, TNTP highlighted this question in their report, *The Irreplaceables*, which documents across several districts that administrators did not differentiate their retention efforts by teacher effectiveness (TNTP, 2012). TNTP's report highlighted the costs of this approach to students, as well as to the stature of teaching. Nearly half of the most-effective teachers in some districts reported that their district made little or no effort to retain them, and "two-thirds told [TNTP] that their principal hadn't even encouraged them to stay" (TNTP, 2012, p. 4). Such failure to differentiate retention efforts meant that students received less effective instruction, and teachers were sent the signal that quality was irrelevant, simultaneously diminishing the professional stature of teachers. While that report received wide attention at the time, it seems few districts have embraced its primary message (Kraft & Gilmore, 2017).

For differential retention to be an effective strategy for improving teaching quality and student achievement: the system for measuring teaching quality should make distinctions that

align with true teaching effectiveness and student outcomes; teachers should be sent differential signals that conform to their measured effectiveness; and there needs to be a sufficient supply of applicants who are, on average, at least as effective as those who leave. In this paper, we explore these issues in the context of the District of Columbia Public Schools (DCPS). We focus on three research questions:

- What effect does teacher turnover have on teaching skills and student achievement in DCPS, and how does this differ by measured teacher effectiveness?
- How does teacher turnover vary by measured teacher effectiveness?
- And what role might the evaluation system play in turnover?

DCPS is a particularly appealing place to explore these questions. For a decade, DCPS has employed one of the most rigorous teacher evaluation systems. DCPS also experiences relatively high teacher turnover, raising concerns about the effect of such turnover on student outcomes. Concerns have also been raised about the role that IMPACT, the DCPS teacher evaluation system, plays in such turnover (Levy, 2018).

BACKGROUND

A large literature examines various aspects of teacher turnover (for recent summaries, see Simon and Johnson, 2015; Kraft, Marinell, and Yee, 2016; Papay, Bacher-Hicks, Page, and Marinell, 2017). Most of this literature, however, focuses on overall turnover in specific school districts or states, factors associated with turnover, and policies that may influence turnover. Little evidence exists on comparative levels of teacher turnover across districts, or differential turnover by teacher effectiveness. A couple of notable exceptions provide a foundation for our research.

First, Papay et al. (2017) employ a common set of measures and business rules for evaluating turnover across 16 districts. They find that one-year district retention rates for all teachers vary between 83 and 90 percent (averaging 87 percent) and three-year retention rates vary between 58 and 75 percent (averaging 71 percent). Understanding turnover patterns across districts is useful, but as the authors acknowledge, teacher turnover is determined by a variety of factors, some which are beyond the control of schools and districts, and can vary over time, as well as across districts. For example, we know that labor market conditions influence teacher turnover (Nagler, Piopiunik, & West, 2015; Strunk, Goldhaber, Knight, & Brown, 2018). This is most vividly illustrated by the Great Recession, which led to several years of depressed teacher employment. Evans, Schwab, and Wagner (forthcoming) estimate that K-12 employment

declined from 2009 through 2012; as a result, teacher turnover was likewise substantially reduced during this period.[1] Teacher turnover is also influenced by local labor market conditions. For example, a robust charter school system increases demand for teachers, likely increasing attrition. In addition, there is evidence that teachers have preferences over the students they teach, and that on average turnover is greater for teachers of low-performing, low-income students (Boyd, Lankford, Loeb, & Wyckoff, 2013; Clotfelter, Ladd, & Vigdor, 2005; Loeb, Kalogrides, & Béteille, 2012). In addition, teachers—especially those early in their careers, when turnover is generally highest—leave for a variety of personal reasons (e.g., relocation of a spouse, childbirth, or career uncertainty). Thus, any benchmarks should be employed judiciously in light of local context. A second motivating line of evidence is that more-effective teachers are less likely to turn over than less-effective teachers, other things equal. Novice teachers with lower value-added turn over at higher—sometimes much higher— rates than their higher value-added peers (Hanushek, Kain, O'Brien, & Rivkin, 2005; Boyd, Grossman, Lankford, Loeb, & Wyckoff, 2008; Papay et al., 2017). The mechanism(s) by which this differential turnover occurs are unclear. Smaller-scale pilots find that information on teacher effectiveness led to increases in the likelihood of turnover among low-performing teachers but had no discernable effect on student achievement (Rockoff, Staiger, Kane, & Taylor, 2012; Sartain & Steinberg, 2016). When New York City principals extended the probationary periods of untenured teachers based on information of weak performance, extended teachers were more likely to turnover than otherwise similar un-extended teachers (Loeb, Miller, & Wyckoff, 2015). These same patterns are also evidenced, however, in settings where teachers or their supervisors did not have access to systematic teacher performance information (Hanushek et al., 2005; Boyd et al., 2008; Papay et al., 2017). Less-effective teachers may recognize that they are less effective or may feel less intrinsically rewarded than their more-effective colleagues, leading to differential attrition. Or, principals may observe they are relatively less effective and counsel them out of teaching.

More recently, researchers have exploited the implementation of teacher evaluation systems across school districts to explore whether these new systems have influenced differential teacher turnover. Cullen, Koedel, and Parsons (2019) find that teacher evaluation implemented at

[1] It may follow that the Papay et al. estimates of teacher retention, many of which employ data that span the recession, are higher than what would be found in non-recessionary periods, when alternative job opportunities are more plentiful.

scale in Houston increased the likelihood of turnover among low-performing teachers (by 6 percent) and decreased the likelihood of turnover (by 4 percent) among high-performing teachers relative to teachers in the middle of distribution, though these effects are too small to produce statistically significant changes in student achievement. Another study of a well-funded, multifaceted assessment of teacher evaluation and related human capital reforms found that teacher evaluation resulted in few systematic effects on student outcomes (Stecher et al., 2018). The analysis concluded that teacher evaluation was often poorly implemented, with little differentiation of teacher effectiveness, widespread ratings inflation by principals, and limited feedback to teachers about their performance.

Ten years ago, DCPS implemented a number of reforms in an attempt to address a long history of disfunction and very low student performance. Central to these reforms was the implementation of a rigorous teacher evaluation system—IMPACT (National Research Council, 2015). IMPACT annually assesses all teachers, employing multiple measures of teacher effectiveness, and attaches meaningful stakes to the ratings produced by this system. IMPACT was controversial from the outset. Teachers had legitimate concerns whether IMPACT would assess them fairly and whether they would receive the feedback and support necessary to improve when weaknesses were identified. IMPACT has three main design components:

- Every teacher is assessed every year using multiple measures of teaching effectiveness, which include multiple standards-based observations of effectiveness by calibrated observers and some measure of student achievement.
- Teachers receive professional development supports in the form of feedback following each formal classroom observation and, in recent years, intensive professional development.[2]
- Teachers who score in the lowest rating categories are subject to dismissal (Ineffective) or the threat of dismissal if they fail to improve (Minimally Effective or Developing). Teachers rated Highly Effective are eligible for large financial rewards and professional opportunities.

While these features remain integral to IMPACT's design, DCPS has made several changes to the design and implementation of IMPACT, many in response to concerns raised by teachers.[3]

[2] In 2016-17, DCPS introduced an intensive professional development program, LEarning Together to Advance our Practice (LEAP), which combines weekly grade- and subject-specific group seminars with one-on-one coaching.
[3] For more details on the development of IMPACT see Toch (2018) and Dee, James, and Wyckoff (2019).

IMPACT operates within the larger market for teachers in the District of Columbia metropolitan area. By design, teaching in DCPS brings high salary potential, which likely improves the pool of teacher applicants. In addition, there is a robust charter school presence in Washington, DC, where close to half of all public-school students attend charter schools. These charter schools could serve as a source of experienced replacement teachers, but the large charter sector can also serve as a source of employment for teachers leaving DCPS but who wish to remain in teaching locally, potentially exacerbating turnover. In addition, the labor market in Washington DC, as well as the surrounding metro area, is tight, meaning that teachers have rich alternative professional opportunities from which choose (Taylor, 2019). All of these contribute to a strong applicant pool from which DCPS can draw replacement teachers (Jacob, Rockoff, Taylor, Lindy, & Rosen, 2018).

IMPACT has been found to improve teacher effectiveness and student achievement. In its earliest years, IMPACT induced a large increase in voluntary turnover among low-performing teachers and increased performance of those low-performing teachers who chose to remain (Dee & Wyckoff, 2015). More specifically, using a regression discontinuity (RD) design, Dee and Wyckoff (2015) found that teachers in 2010-11 and 2011-12 who were rated Minimally Effective—and therefore notified that they had one year to improve, or they would be fired—exhibited a 50 percent increase in voluntary attrition. Minimally Effective teachers who chose to remain improved their performance by 27 percent of a standard deviation (SD). IMPACT's strong financial incentives for Highly Effective teachers were estimated to have no effect on teacher retention but did induce teachers receiving their first Highly Effective rating to improve their IMPACT scores by 24 percent of a SD, in response to potential large base-pay increases. The effects at the lower end of the performance distribution remained substantial through 2015-16 period (Dee, James & Wyckoff, 2019), even after several changes to IMPACT's design. Employing data though 2015-16 Dee, James, and Wyckoff (2019) find that, despite substantial changes to IMPACT and the context in which it operates, it still induces the voluntary exit of low-performing teachers and improvement for those who remain. RD estimates indicate that Minimally Effective teachers exit at a rate that is 40 percent greater than otherwise similar Developing teachers, and Developing teachers exit at a rate that is 40 percent greater than otherwise similar Effective teachers. For Minimally Effective teachers who are retained,

performance increased on average by 27 percent of a SD relative to otherwise similar Developing teachers.

Adnot, Dee, Katz, and Wyckoff (2017) explored the relationship between teacher turnover, teaching quality, and student achievement in DCPS directly. Assessing teacher turnover during the first three years of IMPACT (2009-10 through 2011-12), they found that:

- On average, teacher turnover in DCPS improves teaching quality (0.34 SD of IMPACT scores) and student achievement (0.08 SD),
- When a high-performing teacher exited, teaching quality and student achievement fell, although the effects on student achievement were statistically insignificant.
- When a low-performing teacher exited, teaching quality—as measured by IMPACT—improved by 1.3 SD, and student achievement improved by .21 SD in math and .14 SD in reading, with nearly all of these gains accruing to students in high-poverty schools.

These overall improvements to teaching quality and student learning demonstrate the importance of distinguishing turnover of more and less effective teachers. While these findings were important evidence of differential turnover effects across teacher effectiveness levels under IMPACT, there are good reasons to believe that these turnover effects may not persist. First, the positive effects of turnover of low-performing teachers could have attenuated as the stock of less-effective teachers shrinks through forced and voluntary exits. Second, changes to IMPACT, which substantially reduced the financial incentives for Highly Effective teachers in low-poverty schools, may well have increased turnover for the district's most-effective teachers. Third, as suggested above, teachers find high-stakes evaluation stressful, which could increase turnover across the board, leading to negative effects on teaching skills and student achievement, given that during the period of our analysis about 70 percent of all DCPS teachers are Effective or Highly Effective. Fourth, IMPACT's implementation may suffer over time with changes in leadership or as the policy focus of district leaders shifts to other initiatives. Finally, DCPS has recently invested heavily in a professional development program, LEAP, which is intended to improve the quality of all teachers. If successful, exiting teachers are likely to be more effective in recent years, other things equal, increasing the likelihood that turnover would result in reduced student achievement.

Building on the extant literature, we explore three related questions in this paper. First, we ask, given that IMPACT has both evolved and matured since the period studied by Adnot et al. (2017), what is the effect of teacher turnover on teaching skills and student achievement, and

how does this differ by measured teacher effectiveness. Second, we ask how teacher turnover varies by measured teacher effectiveness. Finally, building on this variation, we ask what role the evaluation system might play in turnover and whether there are factors within the district's control that might facilitate retention of the district's best teachers.

METHODS AND DATA

Our analysis is composed of two parts. In the first, we examine the causal effect of teacher turnover on teaching skills and student achievement with a goal of better understanding the effect of turnover, differentiated by teacher effectiveness. The second portion of our analysis employs descriptive analyses to examine how teacher turnover differs among subgroups of teachers and students in DCPS, as well as exploring the reasons teachers leave DCPS.

The Effect of Teacher Turnover. We examine the effects of teacher exits from DCPS on teaching skills and student achievement employing a panel-based research design similar to prior research (Ronfeldt, Loeb & Wyckoff, 2013; Chetty, Friedman & Rockoff, 2014; Adnot et al., 2017).[4] This design compares the effect of various levels of teacher turnover in school-grade cells on either teaching quality or student achievement in year t on these outcomes in these same school-grade cells in $t + 1$. Changes in teaching effectiveness reflect the average differences between exiting and entering teachers, the disruption that such turnover creates among school-grade colleagues and the proportion of teachers in a school-grade cell who turnover; changes in student achievement depend on similar differences and the effect of differences in teaching skills on student achievement.

We aggregate what is intrinsically a teacher-level analysis to the school-grade level to mitigate two potential problems. First, the effects of turnover likely reach beyond an individual classroom to other classrooms in the same grade (Ronfeldt et al., 2013); this allows our turnover effect estimates to capture potential disruption effects or changes in peer effects, in addition to purely compositional effects of school-grade turnover. Second, aggregation to the school-grade level also mitigates potential internal validity threats, such as when more motivated parents attempt to seek returning teachers in grades with turnover, leaving new teachers with lower-performing students. We then estimate two reduced-form equations, one for each of our

[4] This discussion draws directly on that presented in Adnot et al., 2017.

outcomes of interest—teaching quality (equation 1a) and student achievement (equation 1b). Changes in teaching quality ($\Delta\overline{TQ}_{sgt}$) are measured by changes in IMPACT scores and are a function of: the student-weighted share of teachers in school s and grade g in year $t-1$ who exit DCPS by the beginning of year t, E_{sgt-1}; a year fixed effect, ω_t; and a random error term, $\Delta\varepsilon_{sgt}$.[5] Changes in student achievement are measured by changes in average residualized[6] average achievement, $\Delta\bar{A}^*_{sgt}$, and are a function of: changes in the attributes of grade-level peers, $\Delta\bar{X}_{sgt}$; the student-weighted share of teachers in school s and grade g in year $t-1$ who exit DCPS by the beginning of year t, E_{sgt-1}; a year fixed effect, ω_t; and a random error term, $\Delta\varepsilon^*_{sgt}$.

$$\Delta\overline{TQ}_{sgt} = \gamma_1 E_{sgt-1} + \omega_t + \Delta\varepsilon_{sgt} \qquad (1a)$$

$$\Delta\bar{A}^*_{sgt} = \Delta\bar{X}_{sgt}\beta_2 + \gamma_1 E_{sgt-1} + \omega_t + \Delta\varepsilon^*_{sgt} \qquad (1b)$$

Estimates from these models identify the effects of turnover through a difference-in-differences approach. For example, the change in student performance in a school-grade cell before and after teacher turnover captures the effect of turnover and the effect of other time-invariant influences. A second difference between school-grade cells with and without turnover isolates the effect of those other time-varying factors. The difference of these two isolates the effect of turnover.

Teacher turnover is identified by controlling for time-invariant traits specific to school-grade cells, time-varying characteristics across schools and grades, and student-level characteristics including prior achievement. Nonetheless, the internal validity of teacher turnover estimates in equation 1 rests on several assumptions. First, we assume that students don't sort to or from schools in response to teacher turnover in a way that is correlated with student achievement. Second, our approach assumes that DCPS does not manipulate transfers within

[5] There is a debate whether to control for student attributes when examining measures of teacher quality (see, for example, Whitehurst, Chingos, and Lindquist, 2014; Steinberg and Garrett, 2016; Campbell and Ronfeldt, 2018). For teachers in tested grades IMPACT already controls for student characteristics when estimating value added but does not include such controls for teacher observations. Because this is DCPS's measure of teacher quality, we have chosen to not include these controls in our main estimates; however, robustness checks with models that include these controls (available upon request) are nearly identical to results from the models omitting student characteristics.

[6] We have residualized student achievement for student characteristics such as race, poverty status and special education status.

DCPS such that it biases our estimates. An example that violates this assumption occurs when filling a vacancy created by turnover; a principal might transfer systematically more- or less-effective teachers to the open position. Although there is slight variation across years and subjects, on average 48 percent of replacement teachers come from outside the DCPS system, 14 percent transfer across DCPS schools, and 38 percent transfer within DCPS schools (i.e., across subjects or grades). We also assume in equation 1 that these teacher transfers have no achievement implications for the "sending" school-grade cell (e.g., due to disruption in the quality of peer teachers). Finally, we assume there are no unobserved school-grade factors correlated with turnover and student achievement—for example, changes in principal effectiveness, which could influence both teacher turnover and student achievement.

To address these challenges to internal validity, we modify equations 1a and 1b and conduct several robustness checks. First, we add controls for within- and across-school transfers. Second, recall that our first-differencing eliminates time-invariant school effects; we include school fixed effects to address the potential for school-level changes over time. Third, to explore student sorting, we estimate auxiliary regressions predicting student attributes with teacher turnover. If turnover predicts student attributes it would suggest such sorting. In general, we find little evidence that turnover predicts student attributes. See Appendix Table 1 for these results. Finally, the theory of change associated with IMPACT is that improving teaching quality improves student achievement. Our estimates of the effects of turnover on teaching quality and turnover on student achievement allow us to explore this mechanism.[7] As will be seen in Tables 2 and 3, in every instance where turnover is estimated to positively or negatively affect achievement, we observe an effect of turnover on observed teaching quality that is of the same sign and usually of roughly proportionate magnitude. This increases our confidence that our estimates of the effects of teacher turnover on student achievement reflect the hypothesized relationship and not other factors that may be influenced by teacher turnover.

We extend our analysis to examine heterogeneous effects of turnover by measured teaching quality. In place of the overall effect of turnover, E_{sgt-1}, we test specifications where E^{L}_{sgt-1} denotes the proportion of students in each such cell whose teacher exited the DCPS teaching workforce and was a low-performing (i.e., Developing, Minimally Effective, or

[7] Dividing γ_i from Equation 2a by γ_i' from Equation 2b approximates the Wald estimator, which represents the change in student achievement due to changes in teacher quality that result from teacher turnover.

Ineffective) teacher, and E^{H}_{sgt-1} denotes the proportion of students taught by a high-performing (Effective or Highly Effective) teacher who left the district at the end of year *t-1*. In all specifications, we condition on the prevalence of within-school transfers, S_{sgt-1}, and transfers across schools in the district, D_{sgt-1}. These controls allow us to condition on the effects that turnover may have on school-grade cells that "send" teachers elsewhere within the district. The resulting specification takes the following form:

$$\Delta\bar{A}^{*}_{sgt} = \gamma_1 E^{L}_{sgt-1} + \gamma_2 E^{H}_{sgt-1} + \delta S_{sgt-1} + \theta D_{sgt-1} + \Delta\bar{X}_{sgt}\beta_2 + \omega_t + \varepsilon^{*}_{sgt} \quad (2a)$$

$$\Delta\overline{TQ}_{sgt} = \gamma'_1 E^{L}_{sgt-1} + \gamma'_2 E^{H}_{sgt-1} + \delta' S_{sgt-1} + \theta' D_{sgt-1} + \omega'_t + \varepsilon'_{sgt} \quad (2b)$$

Finally, we examine whether the effect of teacher turnover varies by year or school poverty status by interacting each treatment variable with the respective indicator variable.

The Nature of Teacher Turnover. To explore the level of and reasons for teacher turnover in DCPS we make use of several data sources. First, teacher turnover is assessed using a panel of administrative data which uniquely identifies teachers. We define a teacher as having exited teaching in DCPS if she is a teacher of record earning an IMPACT score in t, and not a teacher of record in $t+1$ and $t+2$.[8] Teachers are linked to IMPACT and school data to better understand teacher turnover by teaching effectiveness and student attributes using simple descriptive statistics.

It is often difficult to know with certainty why exiting teachers decided to leave their positions. We employ a third category of data—exiting teachers' responses to two different surveys linked to administrative data—to assess the factors most important to their decisions. The first survey is the Declaration of Intent Not to Return (DINR), which all teachers who expect to leave DCPS are requested to complete by April 3.[9] Questions on the DINR have changed over the years but, since the 2012-13 academic year, the DINR consistently asks teachers their primary reasons for leaving. Over the 2012-13 through 2016-17 period, we match DINR responses to 52 percent of all DCPS exits. The characteristics of respondents to the DINR survey often differ from those of exiting teachers. Many of these differences are small, but two

[8] All teachers in DCPS who are teaching long enough in the school year to receive at least one classroom observation score receive an IMPACT score. Our focus is on classroom teachers, so someone who is a teacher in t but remains in DCPS in another capacity in $t+1$ is considered as having exited. Teachers who are not present as teachers for more than two years are considered as having exited.

[9] Those who leave the district before the subsequent school year and have not completed the DINR by April 3rd will be fined $1000.

important differences should be noted. DINR respondents tend to be higher performing and more white than the population of teachers who exit (Appendix A Table 2).

ANALYSIS

About 20 percent of all DCPS teachers leave in any given year, with more than 50 percent exiting over a five-year period (Figure 1). This statistic raises many questions. Is this turnover rate too high? Relatedly, which teachers are leaving DCPS? Why are these teachers leaving? Are these teachers dissatisfied with policies or practices that could be readily changed, or are these teachers exiting for reasons largely beyond the control of the district, e.g., a large group of baby-boomers reaching the age of retirement? Can DCPS replace exiting teachers with similarly- or more-effective teachers? The answers to each of these questions are not readily apparent. We explore these questions below.

Teacher Turnover and Student Achievement. On average, the turnover of a teacher in DCPS results in improvements to student achievement in math but not reading. Math achievement increases by 5 percent of a standard deviation, and while the reading estimates are also positive, they are statistically insignificant (Table 1). These effects are also illustrated in Figure 2. However, this average masks substantial variability, depending on the effectiveness of exiting teachers. The attrition of a high-performing teacher (Highly Effective or Effective) reduces the quality of teaching, as measured by IMPACT, with suggestive evidence that student achievement also somewhat declines (Table 1 and Figure 2). We estimate that when a high-performing teacher leaves, teaching skills in that classroom decline by .75 (ELA) and .95 (math) standard deviations of IMPACT scores, on average (31 and 41 IMPACT points, respectively).[10] The effect of a high-performing teacher leaving the classroom on student achievement is never statistically significant. However, when we isolate the effect of turnover by a Highly Effective teacher (see Appendix Table 3), teaching skills decline by more than 1.5 SD and, while there is not a statistically significant effect on math student achievement, reading achievement on average declines .13 SD. This represents more than two months of additional learning (Hill, Bloom, Black, & Lipsey, 2008). This highlights the importance of retaining high-performing teachers—especially teachers identified as Highly Effective—and raises questions about whether and how these teachers can be retained.

[10] One standard deviation of IMPACT is equal to 46.7 points for the math analytic sample and 40.9 IMPACT points for the ELA sample.

When a low-performing (Ineffective, Minimally Effective, or Developing) teacher leaves the classroom, on the other hand, we estimate substantial improvements to teaching quality and to student achievement. Such an exit improves teaching quality by 1.1 (math) and 1.4 (reading) SDs and student achievement by 0.11 (math) and 0.09 (reading) SDs (Table 1 and Figure 2). These effects for low-performing teachers' exits represent large gains to students—an increase in learning of about two months a year. IMPACT is not mechanically responsible for most of these exits, as many are voluntary. However, IMPACT's identification of low performance influences teachers to voluntarily exit, as indicated by Dee, James, and Wyckoff (2019).

The losses associated with a high-performing teacher leaving the classroom, as well as the gains associated with the exit of a low-performing teacher, primarily accrue to students in high-poverty schools, as shown in Table 2. The attrition of a high-performing teacher from a high-poverty school results in a reduction of teaching quality of one SD in reading and math. Effects on student achievement are negative, but not statistically significant. Meanwhile, the exit of a low-performing teacher from a high-poverty school increases teaching quality by well over a standard deviation and student achievement by 0.10 (math) and 0.09 (reading) SDs.

Robustness of results.

We run a series of tests and alternative statistical specifications to assess the internal validity of our estimates. First, if students with different background characteristics were assigned to classrooms with turnover at different rates than others, our results might reflect sorting, rather than the causal effect of turnover on teaching quality and student outcomes. To test whether such sorting has occurred, we replace our outcome variable with student attributes (Appendix Table 1). The results from these tests indicate that little, if any, such sorting is occurring from year to year when subject-grade-cells experience turnover.

A second potential source of endogeneity not directly controlled for in our primary specifications would occur if there were time-varying changes within the school outside of those captured by first-differencing. One such example of this would be changes in school leadership, which might influence both teaching quality and student achievement, in addition to affecting teacher turnover. Appendix Table 2 presents results from specifications that control for school fixed effects, as well as school-by-year fixed effects. In both cases, the estimates are of similar magnitude, though are in some cases underpowered relative to our primary specification.

Finally, there could be other concurrent mechanisms at play within a school that might influence teaching quality and student achievement outside of turnover within a given subject-grade-year cell. For example, turnover in other grades affecting cross-grade collaboration within a school could bias our estimates. We employ two placebo tests, following Adnot et al. (2017), to confirm that such mechanisms are not driving our results. In the first test, we replace the independent variable (i.e., teacher turnover in year t) with turnover in $t + 1$. These results, (Appendix Table 5), indicate that turnover in t+1 has no effect on outcomes in t. In a second test, we add to our analysis a control for turnover in an adjacent (i.e., the next-higher) grade to see if turnover in other grades is predictive of changes in student achievement or teaching quality in a given grade-year-cell, and whether turnover effects for that grade-year-cell differ when conditioned on turnover in other grades. The results of these tests, which are limited to grade levels that are not terminal within their school (i.e., only those grade levels within a school that have higher adjacent grades), are consistent with the main results, and indicate no effects from turnover in adjacent grades (see Appendix Table 6).

Summary

These results lead to three conclusions. First, they document that there are large differences in the effects of losing high- versus low-performing teachers. The estimated differential effect on teaching quality is more than two SDs, and more than about half a year's worth of student achievement in reading. Second, while no teacher evaluation system will perfectly differentiate true teacher effectiveness,[11] IMPACT appears to make useful distinctions. The estimates of the differential effects on teaching quality (i.e., IMPACT scores) align well with estimated student achievement differences. Perhaps more telling, is that when a high-performing teacher leaves the classroom, students experience a modest negative effect on their achievement, while exiting a low-performing teacher results in substantially improved student achievement. We would be concerned if IMPACT rating categories, which carry meaningful stakes, did not result in meaningful differences in student achievement. Finally, the differential effectiveness in student outcomes between high- and low-performing teachers suggests that the goal of improving teaching quality and student achievement is better served by retention

[11] All measurement systems suffer some degree of measurement error. It is also the case that even a multi-measure system like IMPACT may not accurately account for all the dimensions of effective teaching. Ultimately, we want such systems to be as correlated with true effectiveness as possible. That said, even an imperfect system will be preferred to no system if it yields positive gains to students over the long run.

strategies that target high-performing teachers rather than across-the-board retention efforts. We now turn to an analysis of the level and nature of teacher turnover in DCPS.

Teacher Effectiveness and Teacher Retention. Annual teacher attrition from DCPS averages just under 20 percent, with five-year attrition averaging 57 percent from AY2012-13 through AY2016-17 (Figure 1). How should we contextualize this level of turnover? Comparing DCPS turnover to that of a group of urban districts where one- and five-year teacher attrition averages 13 and 43 percent, respectively, (Papay, et al., 2017) raises questions. However, determining whether this rate is appropriate depends on a more nuanced understanding of the costs associated with turnover, as well as the reasons for turnover.

In DCPS, the overall attrition rate masks substantial variation across teacher evaluation ratings (Figure 3). Attrition among Highly Effective teachers (10 percent) is less than a fifth as high as attrition among teachers rated Minimally Effective (55 percent) and less than half of the rate for those rated Developing (26 percent). Among teachers rated either Highly Effective or Effective, presumably the teachers DCPS is most interested in retaining, attrition is 13 percent. Moreover, Highly Effective and Effective teachers constitute 54 percent of all DCPS teacher turnover during the 2012-13 through 2016-17 period. While much smaller than the overall DCPS attrition rate, even losing a relatively small share of Effective or Highly Effective teachers can be costly to students. The analysis above suggests that DCPS replaces Effective teachers with lower-quality teachers (as measured by IMPACT), but with a quality differential that has little observable effect on student achievement. Losing a Highly Effective teacher, on the other hand, is much costlier, both in terms of teaching quality and in terms of student achievement in reading Appendix Table 3).

Teachers leave their positions for a variety of personal and professional reasons. Figure 4 summarizes the top factors (of up to three) in their decision to exit the district, cited by all teachers responding to the DINR survey during the AY 2012-13 through AY 2016-17 period.[12] In contrast to recent protests and teacher strikes in other districts across the country, where teachers have decried insufficient resources and inadequate pay, teachers who are leaving DCPS

[12] For 2015-16 and 2016-17, we have access to the Insight survey, which is administered to all DCPS teachers by TNTP. Insight queries teachers about a range of subjects, including from teachers planning to remain in DCPS, the top factors in their decision to remain at their school, and from teachers planning to exit, the top factors associated with their decision to leave their school. We use these survey responses to confirm that our DINR findings are robust to a separate survey instrument, which they are (not shown).

rarely cite such concerns as factors in their decision to leave the district; fewer than five percent of teachers describe compensation and benefits or the adequacy of school supplies as a factor in their retention decision. The most commonly-cited factor in teachers' decision to leave is relocation from the DC area (selected by 37 percent), followed by IMPACT (27 percent), school leadership (26 percent), and workload (24 percent). While one in four departing teachers cite school leadership as a factor, the least common factor selected was the quality of the teachers' colleagues (3 percent).

When we isolate the factors associated with exits by Effective and Highly Effective teachers (Figure 5), the landscape shifts somewhat. The most commonly cited reason remains relocation outside of the DC area (44 percent). However, high-performing teachers tend to cite school leadership (19% v. 37%) and IMPACT (19% v. 38%) less frequently than low-performing teachers.

IMPACT. Reasonable concerns have been raised about the role that IMPACT may play in causing teachers to exit DCPS. To explore this issue, we further investigate the importance of IMPACT for teachers' retention decisions and how its role as a retention factor may have changed over time. Over the 2013-2017 period, and across all teachers, IMPACT was among the top three cited reasons for leaving DCPS. The salience of IMPACT as a factor in leaving DCPS, however, varies by teacher effectiveness. It was cited most frequently by the least-effective teachers, and with the least frequency by the most-effective teachers (Figure 6). IMPACT was considered a factor for 13 percent of Highly Effective teachers, 23 percent of Effective teachers, 38 percent of Developing teachers, and 37 percent of Minimally Effective teachers.

IMPACT has also been cited less often as a factor for high-performing teachers exiting DCPS in recent years (Figure 7). IMPACT was named as one of the top three factors by 21 percent of exiting Highly Effective teachers in 2013 but by only 3 percent in 2017. Effective teachers identified IMPACT more frequently, but followed a similar pattern, with 26 percent citing IMPACT as among their top factors in 2013 and 12 percent in 2017. Even when high-performing teachers cited IMPACT as a factor in their decision to leave, it was rarely the primary factor. In 2017, less than 2 percent of Highly Effective or Effective teachers identified IMPACT as their top-ranked reason for leaving DCPS (Figure 8). Most recently, concern about IMPACT appears to account for a small share of the turnover among the District's most-effective teachers.

DISCUSSION

Teacher turnover is much discussed by policymakers, researchers, and the popular media. These discussions usually present teacher retention as an unambiguously positive outcome. However, a good portion of teacher turnover in DCPS works to the advantage of students, resulting in small improvements overall to student achievement in math and teacher quality in reading. These net positive effects can be explained by differential rates of turnover across levels of teaching quality and the ability of DCPS to hire from a relatively effective pool of replacements. Forty-six percent of the turnover of teachers from 2012-13 through 2016-17 was by teachers rated by IMPACT as Ineffective, Minimally Effective, or Developing. On average, when these teachers leave, they are replaced by teachers whose IMPACT scores are almost a standard deviation higher and whose students learn about 2 months more in math or reading each year. As our results evidence, DCPS is able to hire relatively effective replacement teachers when teachers leave DCPS. This is crucial and may not be the case in other teacher labor markets.

However, our analysis also shows that exits of Highly Effective teachers—which accounts for twenty percent of all turnover in DCPS—can be costly to students. When such teachers exit, they are typically replaced by someone whose IMPACT scores are about 1.5 standard deviations worse; in reading, this leads to a reduction in student learning of about 2 months. This places a premium on understanding why these teachers leave and developing policies and practices to moderate the losses. IMPACT is not a leading exit factor for the district's best teachers; over a five-year period about 13 percent of exiting Highly Effective teachers cite IMPACT as among their top three reasons for leaving DCPS, and that number has declined substantially in recent years. Far fewer of these teachers rank IMPACT as the primary factor in their decision to leave, typically ranking it behind other factors. Instead, a plurality of Highly Effective teachers indicates that nothing within the control of DCPS or the school would have changed their decision (Figure 9). However, of the factors within DCPS's grasp, more than 10 percent of high-performing teachers cited increased behavioral or instructional support, encouragement or recognition form school leadership, more schedule flexibility, increased compensation or benefits, and improved and clearer growth opportunities.

IMPACT is at an important juncture. The DC City Council has discussed legislation that could subject IMPACT to collective bargaining (Stein, 2019a), and DCPS Chancellor Lewis

Ferebee announced recently that he is conducting a review of IMPACT to explore modifications that would improve teacher evaluation in DCPS (Stein, 2019b). This paper, along with other recent research on IMPACT's incentive structure (Dee et al., 2019), shows that teaching and learning gains under teacher evaluation systems can be sustained over the long term, even in the face of transitions in leadership, meaningful design modifications, implementation fatigue, competing priorities, and pressure from stakeholders. Although some aspects of IMPACT work well, it is likely that changes to IMPACT can at least partially address concerns of key stakeholders without jeopardizing these benefits.

What might the next phase of improvement look like? Improving performance measures to better align with policy goals is an ongoing process. Are there other or better measures? Measurement tools are still being refined to improve their validity and reliability as measures of teaching quality and effectiveness. For example, are there ways to improve the reliability of teacher observations? Understanding what elements of the evaluation process are crucial to improving the quality of teaching requires much more understanding; one important and unanswered question, for example, is whether high stakes are necessary.

Given the unquestioned importance of teachers for student outcomes, teacher evaluation should focus on how best to identify teachers' effectiveness, and when weaknesses are identified, how best to support teachers as they work to improve. In a small percentage of cases, it may be necessary to dismiss teachers whose performance is sufficiently costly to students. Finally, this paper demonstrates that evaluation can be employed more deliberately to retain high-performing teachers. This could include providing high-performing teachers with increased professional opportunities that leverage their skills—such as mentorship of other teachers (Papay, Taylor, Tyler, & Laski, forthcoming)—and with direct communication about their value to the school, what can be done to retain them, and how to make better use of their skills.

References

Adnot, M., Dee, T., Katz, V., & Wyckoff, J. (2017). Teacher turnover, teacher quality, and student achievement in DCPS. *Educational Evaluation and Policy Analysis, 39*(1), 54-76.

Boyd, D., Grossman, P., Lankford, H., Loeb, S., & Wyckoff, J.H. (2008). *Who leaves? Teacher attrition and student achievement* (NBER Working Paper No. W14022). Cambridge, MA: National Bureau of Economic Research.

Boyd, D., Lankford, H., Loeb, S., & Wyckoff, J. (2013). Analyzing the determinants of the matching of public school teachers to jobs: Disentangling the preferences of teachers and employers. *Journal of Labor Economics, 31*(1), 83-117.

Cambell, S. & Ronfeldt, M. (2018). Observational evaluation of teachers: Measuring more than we bargained for? *American Educational Research Journal*, 55(6), 1233-1267.

Carver-Thomas, D. & Darling-Hammond, L. (2019). The trouble with teacher turnover: How teacher attrition affects students and schools. *Education Policy Analysis Archives, 27*(36), 1-27.

Chetty, R., Friedman, J. H., & Rockoff, J. E. (2014). Measuring the impacts of teachers II: Teacher value-added and student outcomes in adulthood. *American Economic Review, 104*(9), 2633-2679.

Clotfelter, C., Ladd, H. F., & Vigdor, J. L. (2005). Who teaches whom? Race and the distribution of novice teachers. *Economics of Education Review, 24*(4), 377-392.

Cullen, J., Koedel, C., Parsons, E. (forthcoming) The compositional effect of rigorous teacher evaluation on workforce quality. *Education Finance and Policy*.

Dee, T. S. & Wyckoff, J. (2015). Incentives, selection, and teacher performance: Evidence from IMPACT. *Journal of Policy Analysis and Management, 34*(2), 267-297.

Dee, T. S., James, J., & Wyckoff, J. (2019). Is effective teacher evaluation sustainable? Evidence from DCPS. *Education Finance and Policy.*

Evans, W. N., Schwab, R. M., & Wagner, K. L. (2019.) The great recession and public education. *Education Finance and Policy, 14*(2), 298-326.

Nagler, M., Piopiunik, M., & West, M. R. (2015). *Weak markets, strong teachers: Recession at career start and teacher effectiveness* (NBER Working Paper No. w21393). Cambridge, MA: National Bureau of Economic Research.

Hanushek, E., Kain, J. F., O'Brien, D. M., & Rivkin, S. G. (2005). *The market for teacher quality* (NBER Working Paper No. 11154). Cambridge, MA: National Bureau for Economic Research.

Hill, C. J., Bloom, H. S., Black, A. R., & Lipsey, M. W. (2008). Empirical benchmarks for interpreting effect sizes in research. *Child Development Perspectives*, *2*(3), 172–177. http://doi.org/10.1111/j.1750-8606.2008.00061.x

Ingersoll, R. M. (2001). Teacher turnover and teacher shortages: An organizational analysis. *American educational research journal, 38*(3), 499-534.

Jacob, B. A., Rockoff, J. E., Taylor, E. S., Lindy, B., & Rosen, R. (2018). Teacher applicant hiring and teacher performance: Evidence from DC public schools. *Journal of Public Economics, 166*(1), 81-97.

Kraft, M. A., & Gilmour, A. (2017). Revisiting *The Widget Effect*: Teacher evaluation reform and the distribution of teacher effectiveness. *Educational Researcher, 46*(5) 234-249.

Kraft, M. A., Marinell, W. H., & Shen-Wei Yee, D. (2016). School organizational contexts, teacher turnover, and student achievement: Evidence from panel data. *American Educational Research Journal*, *53*(5), 1411-1449.

Levy, M. (2018). *Teacher and principal turnover in public schools in the District of Columbia*. Washington, DC: District of Columbia State Board of Education. Retrieved from https://sboe.dc.gov/sites/default/files/dc/sites/sboe/publication/attachments/SBOE%20Teacher%20Turnover%20Report%20-%20FINAL.pdf

Loeb, S., Kalogrides, D., & Béteille, T. (2012). Effective schools: Teacher hiring, assignment, development, and retention. *Education Finance and Policy, 7*(3), 269-304.

Loeb, S., Miller, L. C., & Wyckoff, J. (2015). Performance screens for school improvement: The case of teacher tenure reform in New York City. *Educational researcher*, *44*(4), 199-212.

Nagler, M., Piopiunik, M., & West, M. R. (2015). *Weak markets, strong teachers: Recession at career start and teacher effectiveness* (NBER Working Paper No. w21393). Cambridge, MA: National Bureau of Economic Research.

National Commission on Teaching and America's Future. (2003). *No dream denied: A pledge to America's children [Summary report]*, Washington, DC: National Commission on Teaching and America's Future.

National Research Council. (2015). *An Evaluation of the Public Schools of the District of Columbia: Reform in a Changing Landscape*. Washington, DC: The National Academies Press. https://doi.org/10.17226/21743.

Papay, J. P., Bacher-Hicks, A., Page, L., & Marinell, (2017). The challenge of teacher retention in urban schools: Evidence of variation from a cross-site analysis. *Educational Researcher, 46*(8), 434-448.

Papay, J.P., Taylor, E., Tyler, J., & Laski, M. (forthcoming). Learning job skills from colleagues at work: Evidence from a field experiment using teacher performance data. *American Economic Journal: Economic Policy*.

Rockoff, J. E., Staiger, D. O., Kane, T. J., & Taylor, E. S. (2012). Information and employee evaluation: Evidence from a randomized intervention in public schools. *American Economic Review, 102*(7), 3184-3213.

Ronfeldt, M., Loeb, S., & Wyckoff, J. (2013). How teacher turnover harms student achievement. *American Educational Research Journal, 50*(1), 4-36.

Sartain, L., & Steinberg, M. P. (2016). Teachers' labor market responses to performance evaluation reform: Experimental evidence from Chicago public schools. *Journal of Human Resources*, *51*(3), 615-655.

Simon, N. S. & Johnson, S. M. (2015). Teacher turnover in high-poverty schools: What we know and can do. *Teachers College Record, 117*(3), 1-36.

Stecher, B., Holtzman, D., Garet, M., Hamilton, L., Engberg, J., Steiner, E., … & Chambers, J. (2018). *Improving teaching effectiveness final report: The intensive partnerships for effective teaching through 2015-16. Policy Report.* Santa Monica, CA: RAND Corporation.

Stein, P. (2019a, June 29). With union backing, D.C. council introduces proposed overhaul of controversial teacher evaluation system. *The Washington Post,* Retrieved from https://www.washingtonpost.com/local/education/with-union-backing-dc-council-introduces-proposed-overhaul-of-controversial-teacher-evaluation-system/2019/06/29/f3722a7a-992f-11e9-8d0a-5edd7e2025b1_story.html

Stein, P. (2019b, October 20). Chancellor pledges to review D.C.'s controversial teacher evaluation system. *The Washington Post*, Retrieved from https://www.washingtonpost.com/local/education/chancellor-vows-to-review-the-districts-controversial-teacher-evaluation-system/2019/10/20/6c00405c-f0de-11e9-8693-f487e46784aa_story.html

Steinberg, M. & Garrett, R. (2016). Classroom composition and measured teacher performance: What do teacher observation scores really measure? *Educational Evaluation and Policy Analysis*, 38(2), 293-317.

Strunk, K. O., Goldhaber, D., Knight, D. S., & Brown, N. (2018). Are there hidden costs associated with conducting layoffs? The impact of reduction-in-force and layoff notices on teacher effectiveness. *Journal of Policy Analysis & Management, 37*(4), 755-782.

Taylor, Y. (2019). "Growing labor demand in D.C. is driving up wages" DC Policy Center, found at https://www.dcpolicycenter.org/publications/employment-trends-washington-region/

TNTP. (2012). *The irreplaceables: Understanding the real retention crisis in America's urban schools.* New York, NY: TNTP.

Toch, T. (2018). *A policymaker's playbook: Transforming public school teaching in the nation's capital.* Washington, DC: Future Ed, Georgetown University. https://www.future-ed.org/wp-content/uploads/2018/06/APOLICYMAKERSPLAYBOOK.pdf

Whitehurst, G. J., Chingos, M. M., Lindquist, K. M. (2014). *Evaluating teachers with classroom observations: Lessons learned in four districts.* Washington, DC: Brown Center on Education Policy and Brookings Institute.

Table 1. Effect of turnover on IMPACT scores and student achievement, 2012-13 through 2016-17

	Math				Reading			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	IMPACT Score	Student Achievement	IMPACT Score	Student Achievement	IMPACT Score	Student Achievement	IMPACT Score	Student Achievement
All Exits	5.87	0.050 *			15.48 **	0.028		
	(5.55)	(0.025)			(6.09)	(0.022)		
High-Performer			-44.74 ***	-0.011			-31.02 ***	-0.031
Exits			(6.70)	(0.033)			(6.01)	(0.023)
Low-Performer			50.52 ***	0.105 ***			59.21 ***	0.085 ***
Exits			(7.36)	(0.033)			(6.69)	(0.032)
Student Controls		X		X		X		X
Observations	870	870	870	870	840	840	840	840

NOTE: Models include year fixed effects and controls for teacher movement within and across schools. Student controls account for the year-to-year, across-cohort change in the percent of students in a school-grade-year cell who are Black, Hispanic, other non-White race/ethnicity, limited-English proficient, special education, or FRPL-eligible. Robust standard errors (in parentheses) are clustered at the school-grade level. Pre-treatment (i.e., exit) years span 2012-13 through 2016-17.

*** $p<0.001$; ** $p<0.01$; * $p<0.05$; + $p<0.10$.

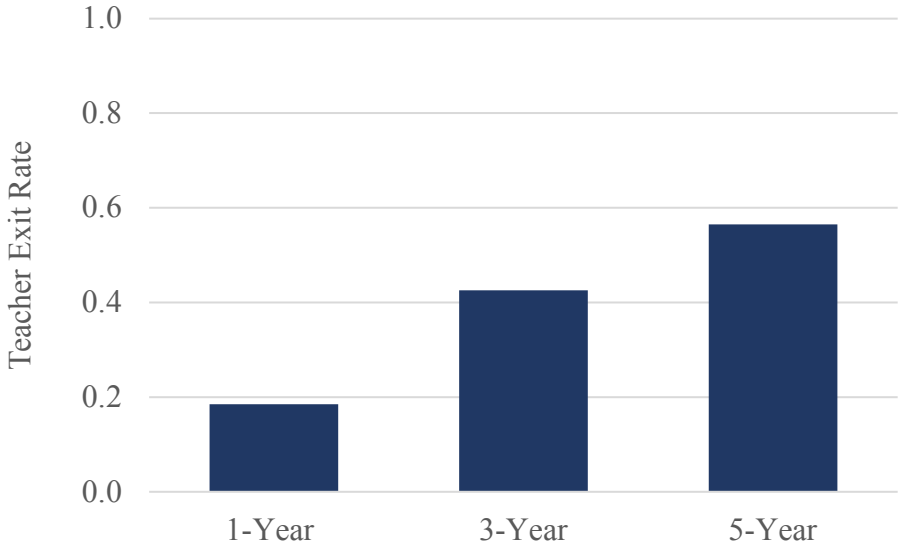
Table 2. Effect of turnover on IMPACT scores and student achievement by school poverty status, 2012-13 through 2016-17

	Math				Reading			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	IMPACT Score	Student Achievement	IMPACT Score	Student Achievement	IMPACT Score	Student Achievement	IMPACT Score	Student Achievement
All Exits								
Low Poverty	-7.82	0.076 +			-12.72 *	-0.036		
	(10.78)	(0.043)			(6.29)	(0.027)		
High Poverty	7.39	0.047 +			20.92 ***	-0.048		
	(5.88)	(0.027)			(6.78)	(0.132)		
High Performers								
Low Poverty			-29.56 *	0.064			-21.23 ***	-0.017
			(13.38)	(0.048)			(6.71)	(0.036)
High Poverty			-48.37 ***	-0.029			-35.23 ***	-0.036
			(7.31)	(0.037)			(7.52)	(0.027)
Low Performers								
Low Poverty			N/A	N/A			N/A	N/A
High Poverty			49.51 ***	0.104 ***			60.17 ***	0.093 ***
			(7.56)	(0.034)			(6.92)	(0.033)
Student Controls		X		X		X		X
Observations	870	870	870	870	840	840	840	840

NOTE: Models include year fixed effects and controls for teacher movement within and across schools. Student controls account for the year-to-year, across-cohort change in the percent of students in a school-grade-year cell who are Black, Hispanic, other non-White race/ethnicity, limited-English proficient, special education, or FRPL-eligible. Robust standard errors (in parentheses) are clustered at the school-grade level. Pre-treatment (i.e., exit) years span 2012-13 through 2016-17. We do not include estimates for low-performer exits in low-poverty schools as these are found in only five school-grade-year observations during this period.

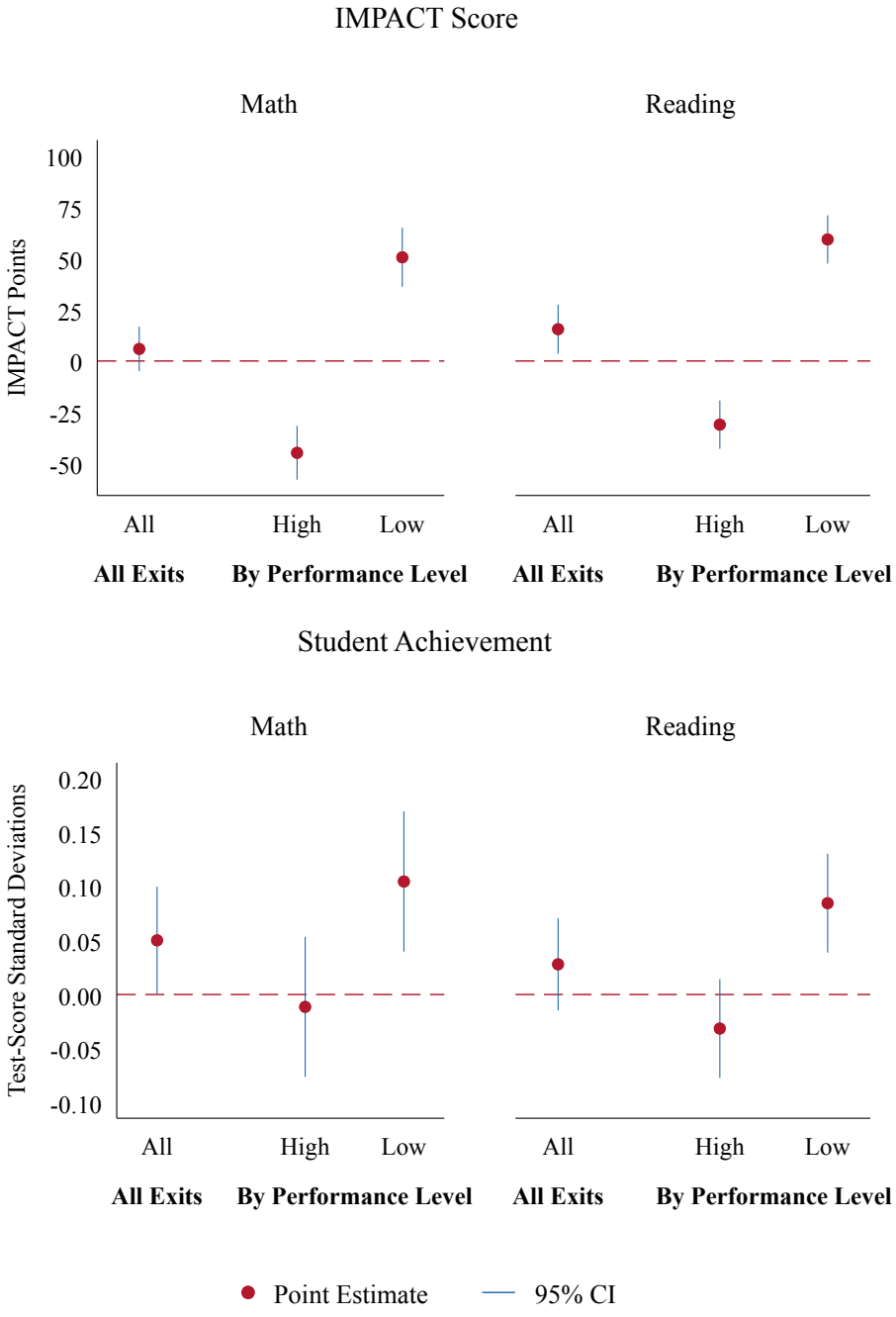
*** $p<0.001$; ** $p<0.01$; * $p<0.05$; + $p<0.10$.

Figure 1. Proportion of teachers exiting DCPS over 1, 3 and 5 years, 2012-13 through 2016-17



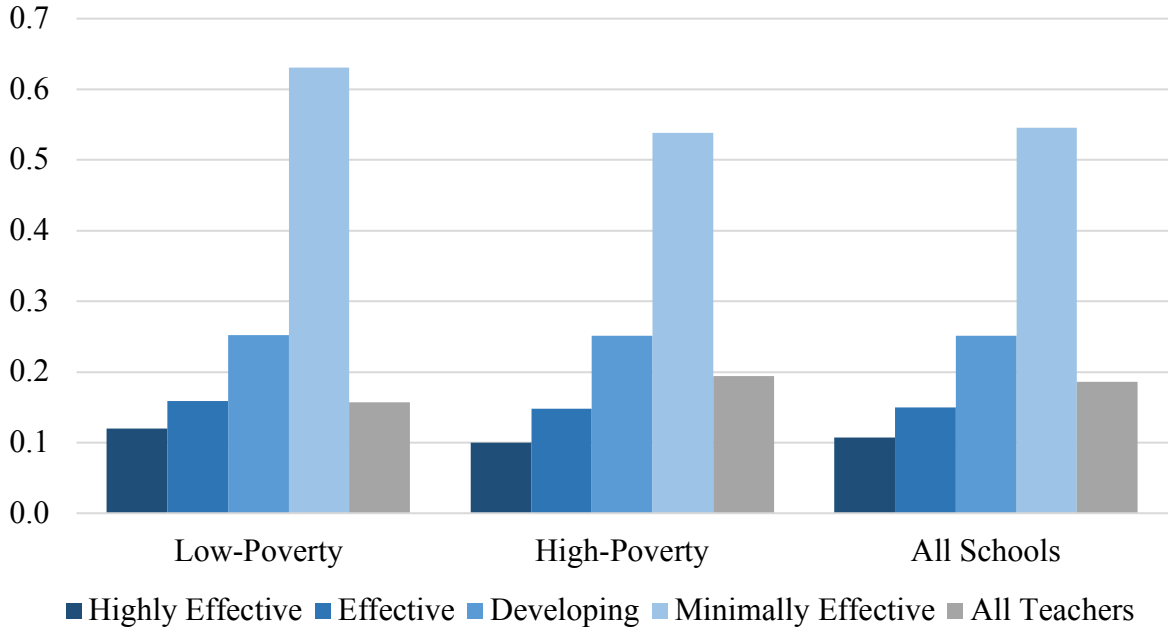
NOTE: For all years except 2017, a teacher is retained if they taught and received an IMPACT rating in t and were a classroom teacher with an IMPACT rating in t+1 or t+2. For 2017 teachers, retention includes those who were a classroom teacher with an IMPACT rating in t+1 (2018).

Figure 2. Effects of teacher turnover on student achievement and teaching quality



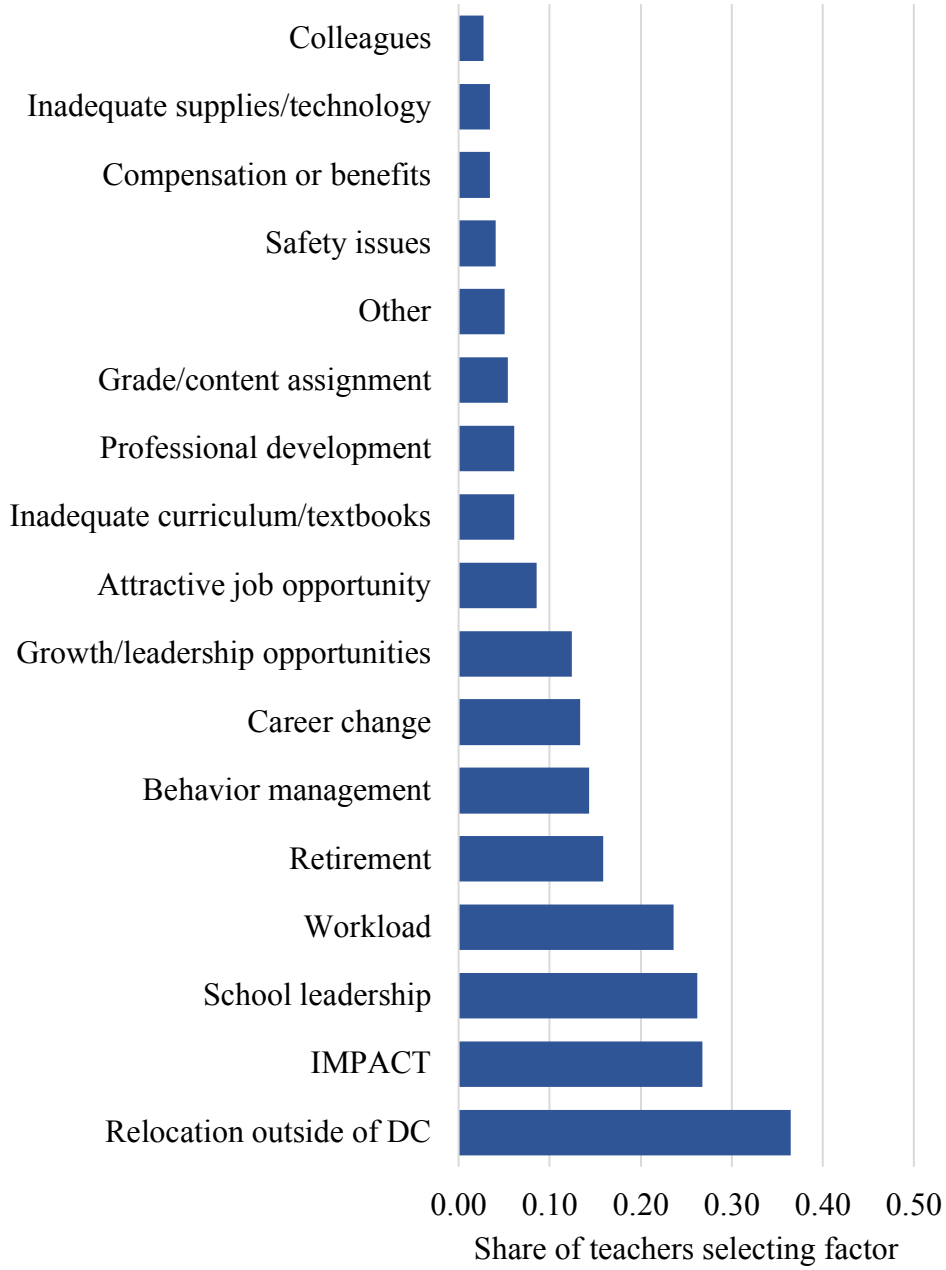
NOTE: Models include year fixed effects and controls for teacher movement within and across schools. Student achievement estimates additionally control for the year-to-year, across-cohort change in the percent of students in a school-grade-year cell who are Black, Hispanic, other non-White race/ethnicity, limited-English proficient, special education, or FRPL-eligible.

Figure 3. Proportion of teachers exiting DCPS by teacher performance level and school poverty, 2012-13 through 2016-17



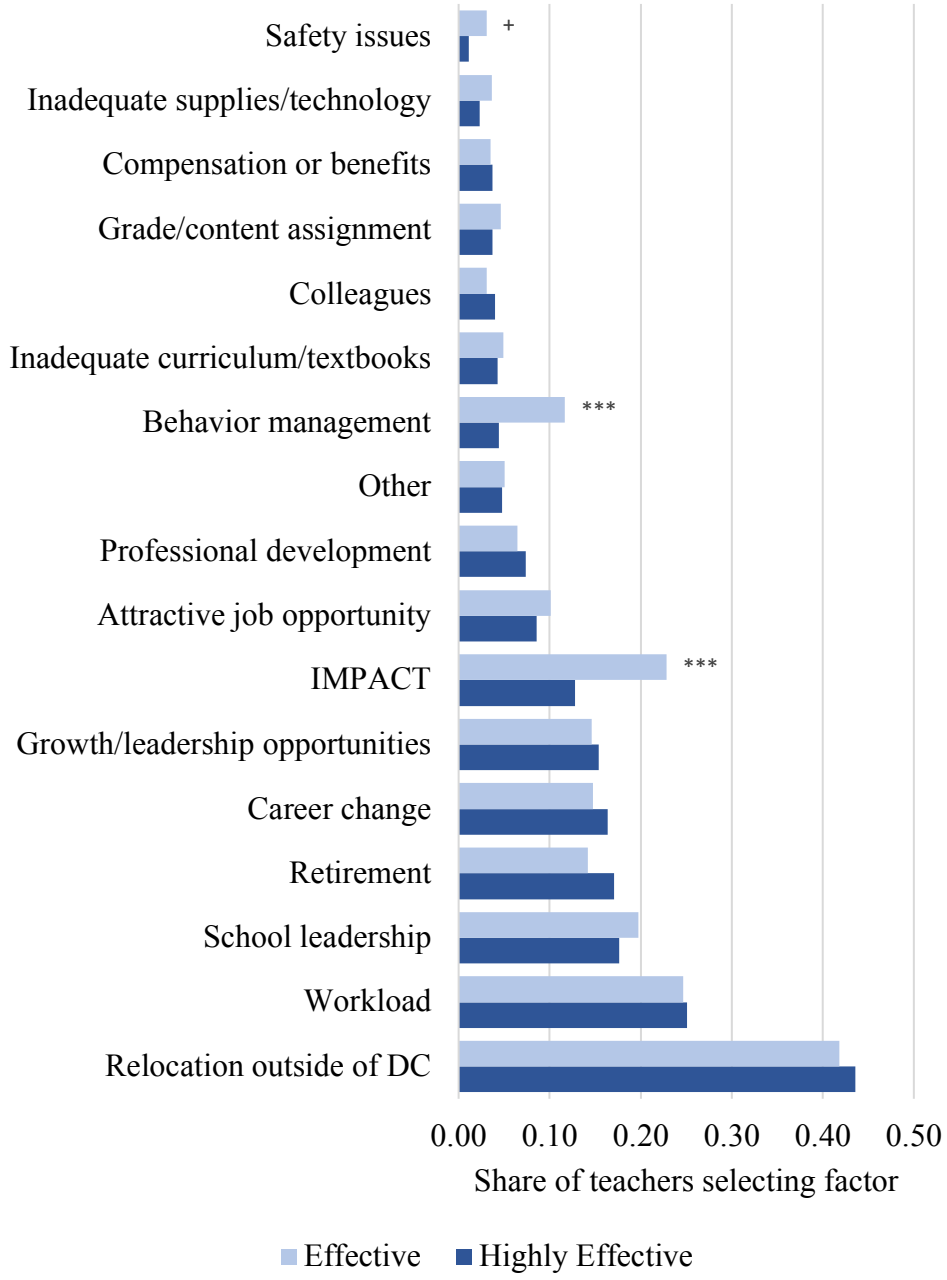
NOTE: For all years except 2017, a teacher is retained if they taught and received an IMPACT rating in t and were a classroom teacher with an IMPACT rating in t+1 or t+2. For 2017 teachers, retention includes those who were a classroom teacher with an IMPACT rating in t+1 (2018).

Figure 4. Factors identified as one of top three in decision to leave teaching in DCPS, from all exiting teachers' DINR survey responses, 2013-2017, all teachers



NOTE: Sample comprises responses to the Declaration of Intent not to Return survey from teachers who gave notice to DCPS that they did not intend to continue teaching. Teachers were asked to select and rank up to 3 core factors in their decision to leave DCPS; the same teacher may therefore count toward multiple factors. The sample is restricted to exclude respondents who remained teaching in DCPS or whose retention status cannot yet be confirmed (i.e., respondents from the 2017-18 academic year). *N*=1,779.

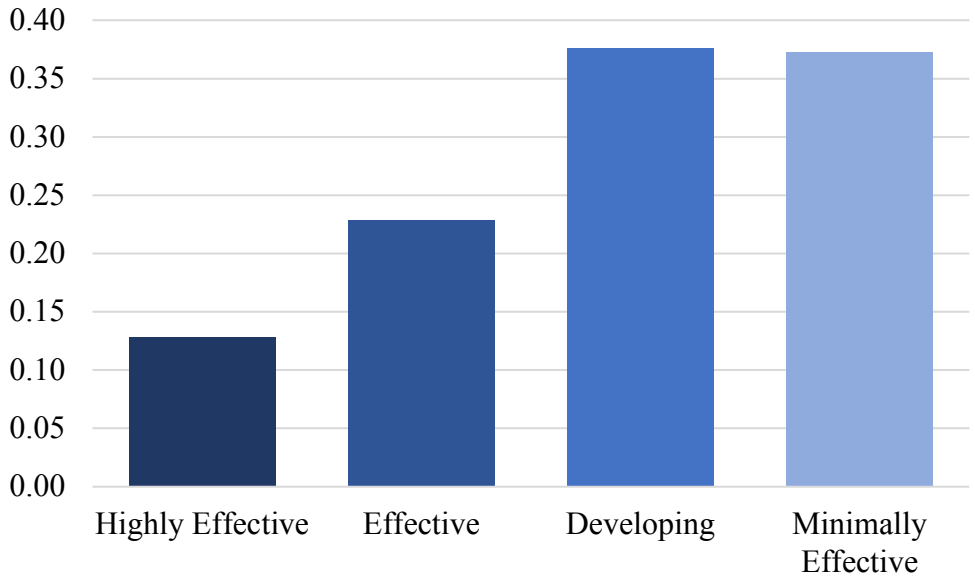
Figure 5. Factors identified as one of top three in decision to leave teaching in DCPS, from exiting Effective and Highly Effective teachers' DINR survey responses, 2013-2017.



*** $p<0.001$; ** $p<0.01$; * $p<0.05$; + $p<0.10$.

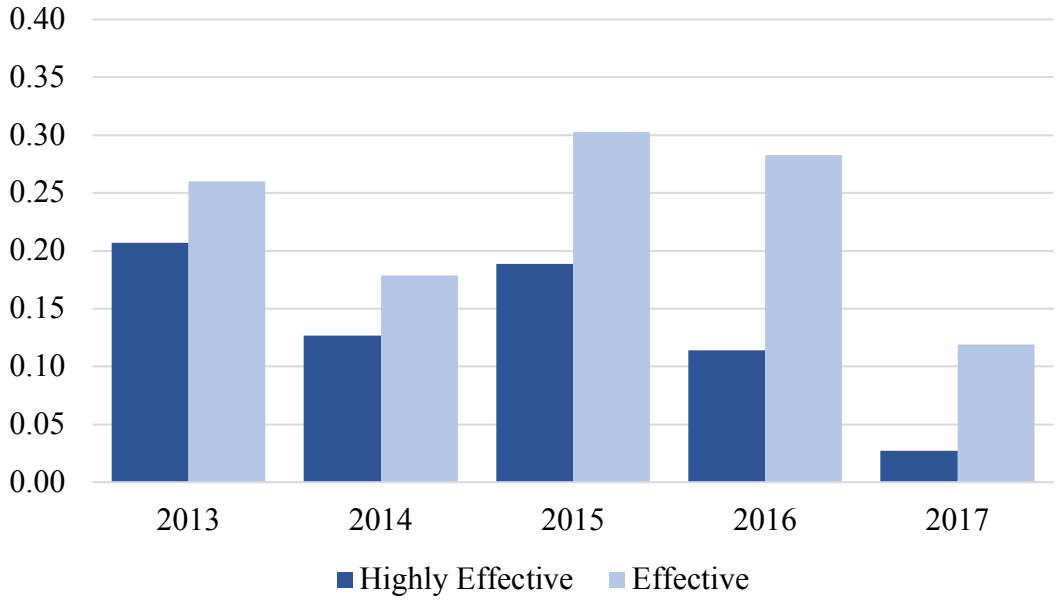
NOTE: See note to Figure 3.

Figure 6. Share of teachers defining IMPACT as one of the top three factors in their decision to leave teaching in DCPS, from exiting teachers' DINR survey responses by IMPACT rating (AY2013-AY2017)



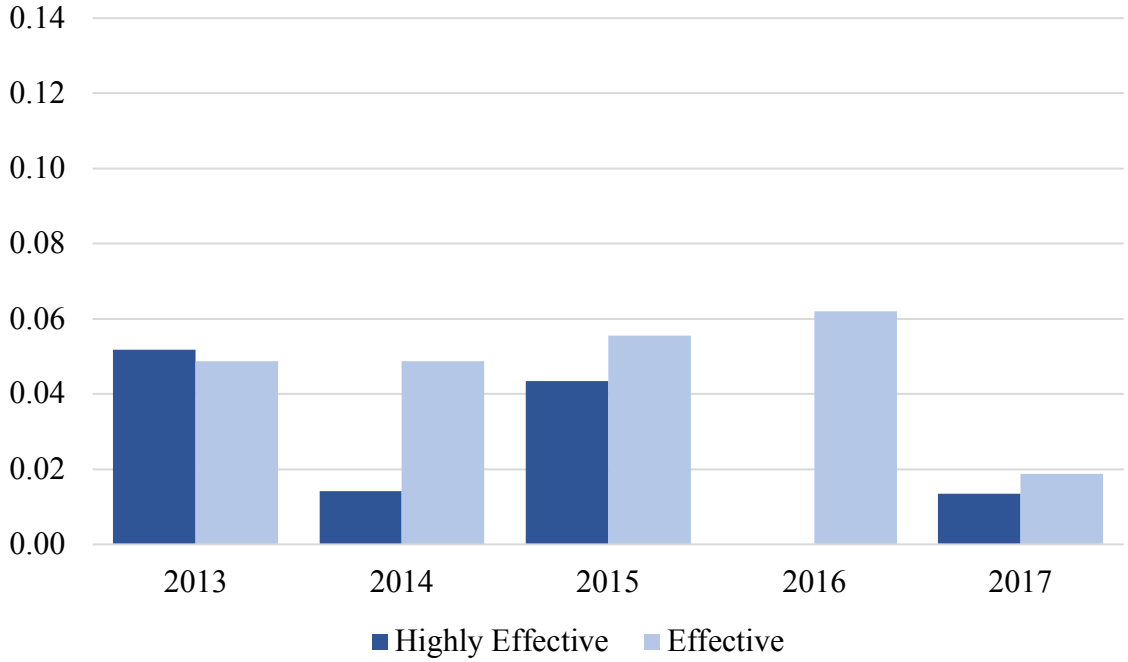
NOTE: See note to Figure 3.

Figure 7. Share of Effective and Highly Effective teachers defining IMPACT as one of the top three factors in their decision to leave teaching in DCPS, by year.



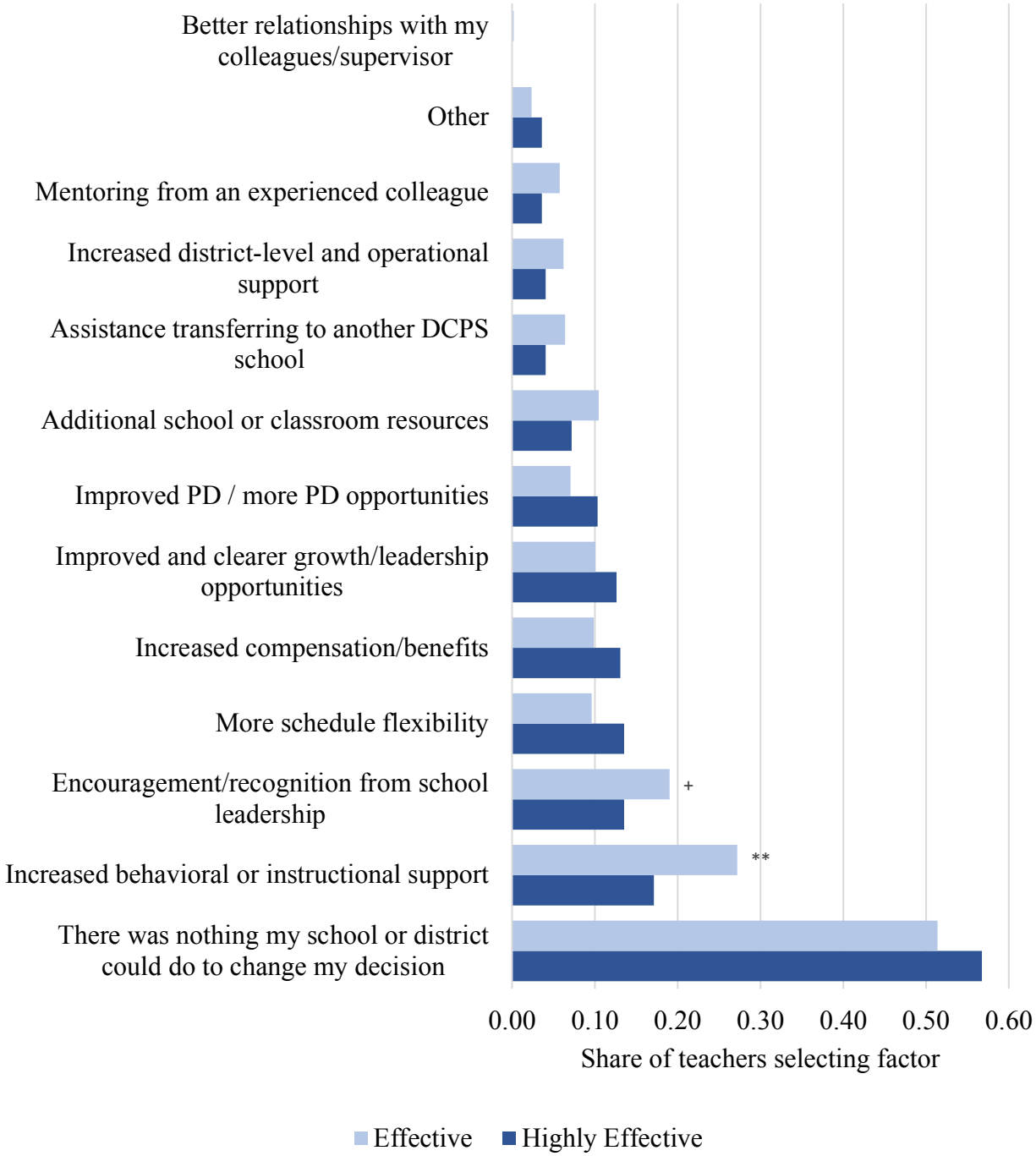
NOTE: See note to Figure 3.

Figure 8. Share of Effective and Highly Effective teachers defining IMPACT as the top factor in their decision to leave teaching in DCPS, by year.



NOTE: See note to Figure 3.

Figure 9. Top three efforts DCPS could have made to retain the teacher in the district, from exiting teachers' DINR survey responses, 2012-13 – 2016-17, by performance level



NOTE: Sample comprises responses to the Declaration of Intent not to Return survey from teachers who gave notice to DCPS that they did not intend to continue teaching. Teachers were asked to select and rank up to 3 core efforts DCPS might have made that would have altered their decision to leave DCPS; the same teacher may therefore count toward multiple efforts. The sample is restricted to exclude respondents who remained teaching in DCPS or whose retention status cannot yet be confirmed (i.e., respondents from the 2017-18 academic year). *N*=1,779.

Appendix

Appendix Table 1. Effect of teacher turnover on changes in student demographics

	Δ Black		Δ Hispanic		Δ Other Race		Δ FRPL		Δ SpEd		Δ LEP	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
						Math						
All Exits	0.013		0.002		-0.001		0.003		-0.006		0.007 $^{+}$	
	(0.009)		(0.007)		(0.009)		(0.008)		(0.008)		(0.004)	
High-Performer Exits		0.007		0.007		-0.011		-0.003		-0.003		0.008
		(0.013)		(0.009)		(0.009)		(0.010)		(0.009)		(0.006)
Low-Performer Exits		0.019 $^{+}$		-0.003		0.008		0.007		-0.009		0.006 $^{+}$
		(0.011)		(0.008)		(0.013)		(0.010)		(0.010)		(0.003)
Observations	870	870	870	870	870	870	870	870	870	870	870	870
						Reading						
All Exits	0.020 *		-0.005		-0.001		0.001		-0.012		0.003	
	(0.009)		(0.006)		(0.011)		(0.008)		(0.008)		(0.004)	
High-Performer Exits		0.010		-0.001		-0.016		-0.004		-0.010		0.001
		(0.012)		(0.010)		(0.014)		(0.010)		(0.011)		(0.005)
Low-Performer Exits		0.030 **		-0.009		0.013		0.005		-0.014		0.006
		(0.012)		(0.007)		(0.012)		(0.010)		(0.008)		(0.005)
Observations	840	840	840	840	840	840	840	840	840	840	840	840

NOTE: Models include year fixed effects and controls for teacher movement within and across schools. Robust standard errors (in parentheses) are clustered at the school-grade level. Pre-treatment (i.e. exit) years span 2012-13 through 2016-17.

*** $p<0.001$; ** $p<0.01$; * $p<0.05$; $^{+}$ $p<0.10$.

Appendix Table 2. Sample characteristics, all exits versus DINR-respondent exits, 2012-13 – 2016-17

	All Exiters	DINR Respondents	
n	*3,374*	*1,747*	
IMPACT Score	294	304	***
High Performing	0.54	0.60	***
Group 1	0.18	0.19	
Gender			
Female	0.70	0.73	***
Missing	0.06	0.06	
Race/Ethnicity			
Black	0.44	0.33	***
Hispanic	0.05	0.06	*
White	0.29	0.38	***
Other	0.04	0.04	*
Missing	0.18	0.19	
Education			
Graduate Degree	0.62	0.61	
Missing	0.09	0.06	***
Experience			
0 years	0.06	0.06	
1-3 years	0.27	0.34	***
4-8 years	0.25	0.26	
9 years or more	0.39	0.33	***
Missing	0.03	0.02	**
School Type			
Education Campus	0.21	0.21	
Elementary School	0.43	0.45	**
Middle School	0.13	0.15	***
High School	0.20	0.18	*
Other	0.04	0.01	***

NOTE: Group 1 teachers are those who teach tested grades and subjects. Schools in the "other" category include special programs, STAY schools, which serve students 16 or older, and special-education schools. High-performing teachers are those rated Effective or Highly Effective; note, however, that the cut score for an Effective rating has changed over the course of this panel, as have the criteria used to assign IMPACT scores. Exit years are defined here by the last year in which an individual taught in DCPS.

*** $p<0.001$; ** $p<0.01$; * $p<0.05$; + $p<0.10$.

Appendix Table 3. Effect of teacher turnover on IMPACT scores and student achievement, by rating

	Math			Reading		
	(1)		(2)	(1)		(2)
	IMPACT		Student	IMPACT		Student
HE Exits	-77.33	***	0.002	-67.96	***	-0.133 ***
	(10.98)		(0.050)	(10.52)		(0.042)
E Exits	-34.11	***	-0.037	-25.98	***	0.001
	(7.40)		(0.038)	(6.69)		(0.028)
Student Controls			X			X
Observations	870		870	840		840

NOTE: Models include year fixed effects and controls for teacher movement within and across schools. Student controls account for the year-to-year, across-cohort change in the percent of students in a school-grade-year cell who are Black, Hispanic, other non-White race/ethnicity, limited-English proficient, special education, or FRPL-eligible. Robust standard errors (in parentheses) are clustered at the school-grade level. Pre-treatment (i.e. exit) years span 2012-13 through 2016-17. Models also include controls for low-performing teacher exits.
*** $p<0.001$; ** $p<0.01$; * $p<0.05$; $^{+}$ $p<0.10$.

Appendix Table 4. Effect of teacher turnover on IMPACT scores and student achievement, conditional on school fixed effects

	IMPACT Score				Student Achievement			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
				Math				
All Exits	6.87	9.66 **			0.059 +	0.055 **		
	(6.60)	(8.07)			(0.03)	(0.034)		
High-Performer Exits			-44.45 ***	-39.95 ***			-0.005	-0.019
			(7.90)	(10.03)			(0.04)	(0.037)
Low-Performer Exits			55.67 ***	55.69 ***			0.124 ***	0.129 ***
			(8.19)	(9.74)			(0.041)	(0.048)
Student Controls					X	X	X	X
School FE	X		X		X		X	
School-By-Year FE		X		X		X		X
Observations	870	870	870	870	870	870	870	870
				Reading				
All Exits	17.85 ***	13.57 **			0.034	0.051 **		
	(6.87)	(7.58)			(0.026)	(0.031)		
High-Performer Exits			-30.52 ***	-26.82 ***			-0.027	0.026
			(6.87)	(8.00)			(0.027)	(0.034)
Low-Performer Exits			65.24 ***	52.74 ***			0.095 **	0.076
			(7.44)	(7.21)			(0.038)	(0.050)
Student Controls					X	X	X	X
School FE	X		X		X		X	
School-By-Year FE		X		X		X		X
Observations	840	840	840	840	840	840	840	840

NOTE: Models include year fixed effects and controls for teacher movement within and across schools. Student controls account for the year-to-year, across-cohort change in the percent of students in a school-grade-year cell who are Black, Hispanic, other non-White race/ethnicity, limited-English proficient, special education, or FRPL-eligible. Robust standard errors (in parentheses) are clustered at the school-grade level. Pre-treatment (i.e. exit) years span 2012-13 through 2016-17.

*** $p<0.001$; ** $p<0.01$; * $p<0.05$; + $p<0.10$.

Appendix Table 5. Effect of next-year teacher turnover on IMPACT scores and student achievement

	Math				Reading			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	IMPACT Score	Student Achievement	IMPACT Score	Student Achievement	IMPACT Score	Student Achievement	IMPACT Score	Student Achievement
All Exits	3.84	-0.050			0.04	0.011		
	(6.53)	(0.032)			(6.18)	(0.029)		
High-Performer Exits			-0.37	-0.081 *			-2.76	0.063
			(7.51)	(0.037)			(7.56)	(0.041)
Low-Performer Exits			9.62	-0.007			2.83	-0.040
			(9.59)	(0.046)			(8.29)	(0.030)
Student Controls		X		X		X		X
Observations	696	696	696	696	672	672	672	672

NOTE: Models include year fixed effects and controls for next-year teacher movement within and across schools. Student controls account for the year-to-year, across-cohort change in the percent of students in a school-grade-year cell who are Black, Hispanic, other non-White race/ethnicity, limited-English proficient, special education, or FRPL-eligible. Robust standard errors (in parentheses) are clustered at the school-grade level. Pre-treatment (i.e. exit) years span 2012-13 through 2015-16, as next-year turnover is not available for 2016-17.

*** $p<0.001$; ** $p<0.01$; * $p<0.05$; + $p<0.10$.

Appendix Table 6. Effect of next-grade teacher turnover on IMPACT scores and student achievement

	Math				Reading			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
	IMPACT Score	Student Achievement	IMPACT Score	Student Achievement	IMPACT Score	Student Achievement	IMPACT Score	Student Achievement
All Exits, Current Grade	7.36	0.067 **	9.13	0.072 **	17.50 *	0.012 **	16.92 *	0.013 **
	(7.36)	(0.033)	(7.57)	(0.032)	(7.64)	(0.026)	(7.78)	(0.026)
All Exits, Next Grade			-8.78	-0.027			2.79	-0.001
			(5.87)	(0.024)			(7.22)	(0.027)
Student Controls		X		X		X		X
Observations	551	551	551	551	500	500	500	500

NOTE: Models include year fixed effects and controls for teacher movement within and across schools, for the sub-sample of non-terminal school-grade-cells. Student controls account for the year-to-year, across-cohort change in the percent of students in a school-grade-year cell who are Black, Hispanic, other non-White race/ethnicity, limited-English proficient, special education, or FRPL-eligible. Robust standard errors (in parentheses) are clustered at the school-grade level. Pre-treatment (i.e. exit) years span 2012-13 through 2016-17.
*** $p<0.001$; ** $p<0.01$; * $p<0.05$; + $p<0.10$.

Appendix Figure 1. Factors identified as one of top three in decision to leave teaching in DCPS, from exiting Effective and Highly Effective teachers who are not relocating or retiring, 2013-2017.